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# PART I

*Bioventing Pilot Test Work Plan for*

**TANK FARM #2, TANK FARM #4, SA 6,
PRL T-46, BUILDING 720**

**McClellan Air Force Base, California**

***and***

**DAVIS GLOBAL COMMUNICATIONS SITE**

**Davis, California**

# PART II

*Draft Bioventing Pilot Test Interim Results Report for*

**TANK FARM #2, TANK FARM #4, SA 6,
PRL T-46, BUILDING 720**

**McClellan Air Force Base, California**

***and***

**DAVIS GLOBAL COMMUNICATIONS SITE**

**Davis, California**

## VOLUME 1 OF 2

***Prepared for***

**Air Force Center for Environmental Excellence
Brooks AFB, Texas
and
Environmental Management
McClellan Air Force Base, California**

**February 1994**

***Prepared by***


**ENGINEERING-SCIENCE, INC.**
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# PART I

*Bioventing Pilot Test Work Plan for*

# TANK FARM #2, TANK FARM #4, SA 6, PRL T-46, BUILDING 720
# MCCLELLAN AIR FORCE BASE, CALIFORNIA
*and*
# DAVIS GLOBAL COMMUNICATIONS SITE
# DAVIS, CALIFORNIA

*Prepared for*

**Air Force Center for Environmental Excellence**
**Brooks AFB, Texas**
**and**
**Environmental Management**
**McClellan Air Force Base, California**

**February 1994**

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## TABLE OF CONTENTS

## PART I

**Bioventing Pilot Test Work Plan for**
**Tank Farm #2, Tank Farm #4, SA 6, PRL T-46, Building 720**
**McClellan Air Force Base, California**
**and**
**Davis Global Communications Site**
**Davis, California**

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

## LIST OF TABLES

# BIOVENTING PILOT TEST WORK PLAN FOR TANK FARM #2, TANK FARM #4, SA 6, PRL T-46, BUILDING 720 MCCLELLAN AFB, CALIFORNIA

***and***

# DAVIS, CALIFORNIA DAVIS GLOBAL COMMUNICATIONS SITE

## 1.0 INTRODUCTION

This Pilot Test Work Plan presents the scope of *in situ* bioventing pilot tests for treatment of fuel contaminated soils at five sites at McClellan Air Force Base, Sacramento County, California and one site at the Davis Global Communications Site (Davis Site), Yolo County, California, which is operated by McClellan AFB. McClellan AFB is located near Sacramento, California, approximately 100 miles northeast of San Francisco. The Davis Site is located in Davis, California, approximately 20 miles southwest of McClellan AFB.

### 1.1 Bioventing Pilot Test Organization

The bioventing pilot test which will be conducted at each of the six sites has three primary objectives. These are: 1) to assess the potential for supplying oxygen throughout the fuel hydrocarbon-contaminated soil zone, 2) to determine the rate at which indigenous microorganisms will degrade the fuel in the soil when stimulated by oxygen-rich soil gas, and 3) to evaluate the potential for sustaining these rates of fuel biodegradation until the contamination is remediated below regulatory standards.

The bioventing pilot test at each site will be divided into two test events. An initial pilot test will determine the technical feasibility and important design parameters such as air permeability, radius of influence, fuel biodegradation rates, and potential air emissions (via soil gas escaping from the subsurface to the atmosphere during air injection). An extended (one-year) pilot test will determine the longer term application of this remedial technology to degrade hydrocarbons at each individual site. If bioventing proves to be applicable, pilot test data could be used to design and implement a bioventing remediation system. A significant amount of the fuel contamination should be biodegraded during the extended (one-year) pilot tests since the bioventing will take place within the most contaminated soils at each site.

Additional background information on the development and recent success of the bioventing technology is found in the document entitled "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing" (Hinchee et al. 1992). This protocol document will also serve as the primary reference for the pilot test well designs and detailed procedures which will be used during the test.

Much of the background information used in this Bioventing Pilot Test Work Plan is derived from prior studies and reports which are listed in Section 8.0.

### 1.2 McClellan AFB Background

McClellan AFB is located approximately 7 miles northeast of downtown Sacramento and covers approximately 3,000 acres (Figure 1.1). Employing approximately 15,000 civilian and military personnel, the base provides worldwide logistics support for weapons systems, equipment, and commodity items as well as maintenance, supply, and contracting services. The base was established in 1936 and since that time has managed, maintained, and repaired various aircraft, electronics equipment, and communications equipment. These operations have generated various hazardous and toxic wastes, including: industrial solvents, electroplating wastes, heavy metals, PCB contaminated oils, contaminated jet fuels, and a variety of oils and lubricants.

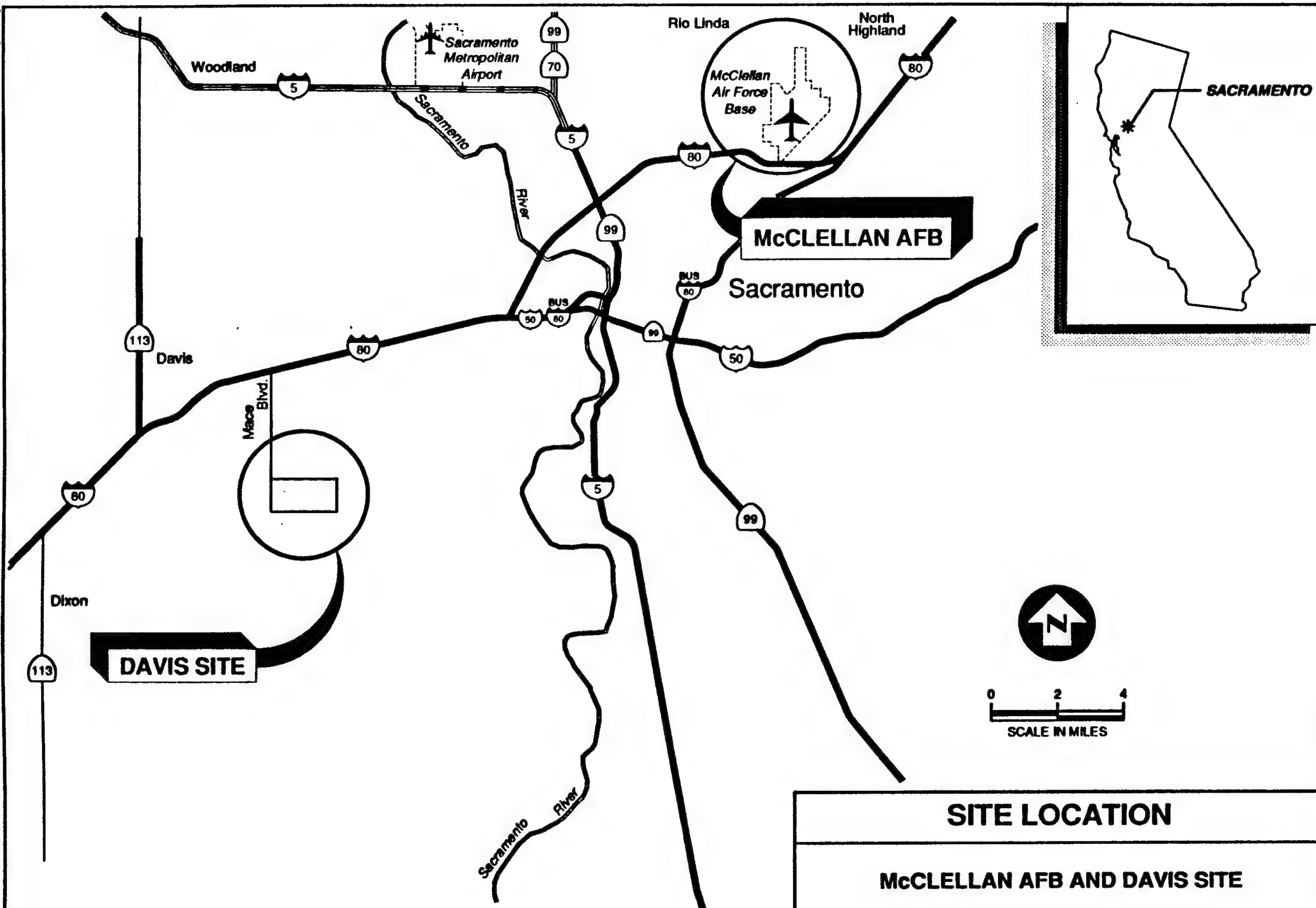
Hazardous wastes were disposed of at a variety of burial pits, sludge pits, and miscellaneous disposal trenches and pits. In 1979, groundwater contamination was discovered and subsequently base production wells were shut down. Since that time, base production wells have been retrofitted with treatment systems, numerous monitoring wells have been installed, and three groundwater extraction systems have been installed to prevent migration of contaminants. A groundwater treatment plant was constructed in 1985.

Numerous environmental investigations have been performed throughout McClellan AFB as part of the U. S. Air Force (USAF) Installation Restoration Program (IRP). Possible sources of contamination at McClellan AFB identified in prior studies are grouped by geographic area, designated as Operable Units (OU) A through H (Figure 1.2). Of the five sites at McClellan AFB proposed for bioventing, two are in OU A (Tank Farm #2 and Tank Farm #4), two are in OU B (SA 6 and PRL T-46), and one is in OU C (Building 720).

### 1.3 McClellan AFB Geology and Environmental Setting

McClellan AFB is situated within the Sacramento Valley, a deep sedimentary trough of sediments shed from the Sierra Nevada mountains and transported by numerous tributaries to the meandering Sacramento River. The valley is covered by alluvial and fluvial deposits. These deposits are mostly fine-grained, but approximately 25 to 30 percent of the deposits are sand and gravel. Accumulation of the sediments can be locally several thousand feet in thickness.

The base is underlain by the Victor formation, which can be up to 50 feet thick (California Department of Water Resources 1974). The sediments within the Victor formation consist of interbedded granitic sand, silt, and clay with occasional lenses of metamorphic channel gravels. These sediments are heterogeneous and laterally and vertically discontinuous, probably the result of past fluvial activity. Hardpan is commonly encountered in the upper part of the stratigraphic column.




# SITE LOCATION

## McCLELLAN AFB AND DAVIS SITE

FIGURE 1.1

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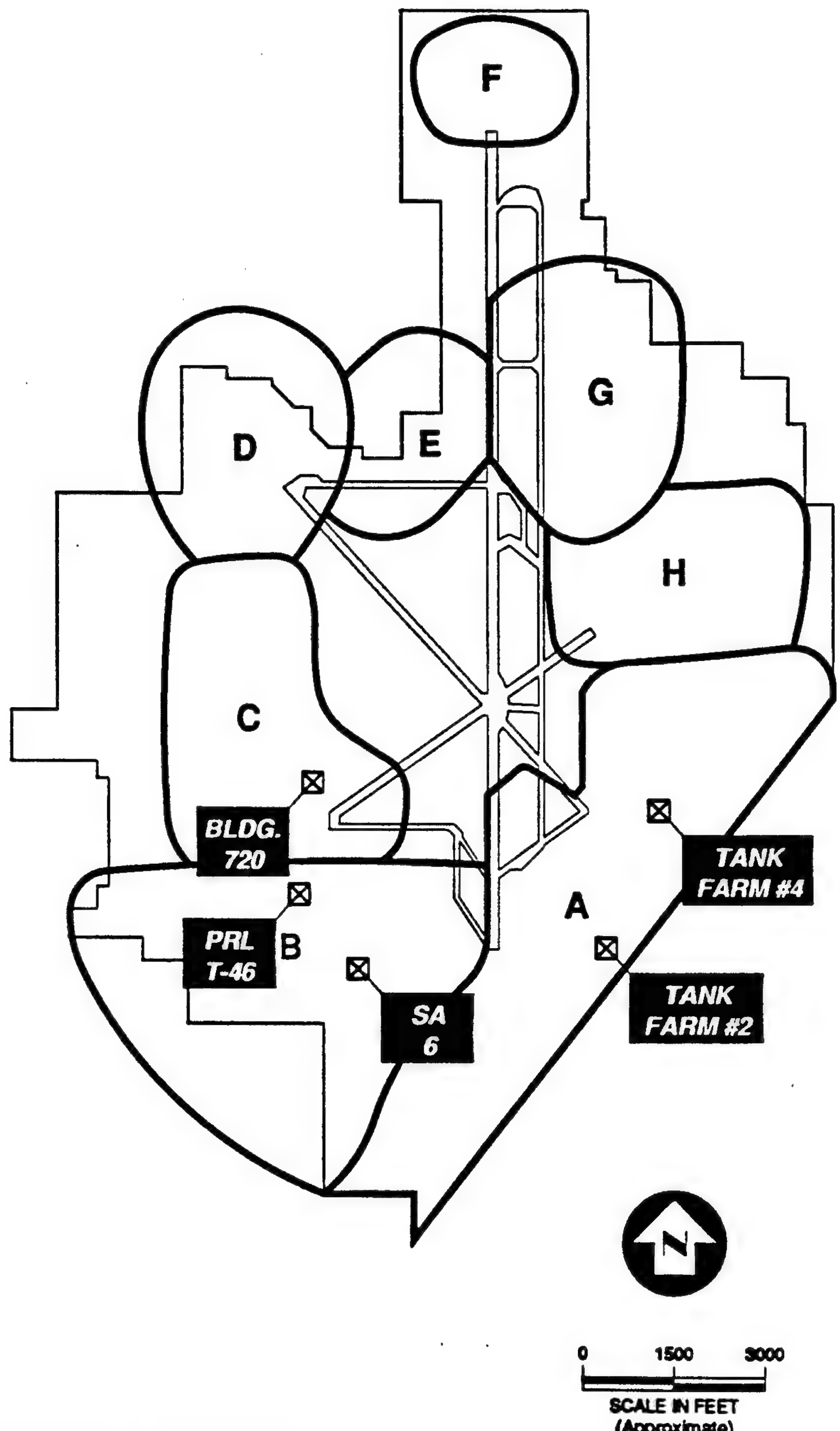
FIGURE 1.2




## EXPLANATION

- BOUNDARIES OF OPERABLE UNITS
- McCLELLAN AFB BOUNDARY
- ⊠ PROPOSED BIOVENTING PILOT TEST SITES

SOURCE: Modified from Radian Corp., 1992

# APPROXIMATE BOUNDARIES OF OPERABLE UNITS

## McCLELLAN AFB, CALIFORNIA

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Underlying the Victor formation is the Fair Oaks formation and/or the Laguna formation, which can be up to 100 feet thick. Sediments in these formations consist of poorly bedded silts, clays, and sands, with occasional lenses of gravel.

The alternating layers of channels, overbank deposits, backwater deposits, sand bars, and widespread flood deposits today form an aquifer system that is extremely variable in nature over short distances, but broadly interconnected. This aquifer system has been separated into a series of zones for purposes of groundwater monitoring, and are designated A though F, from shallowest to deepest. The water table is typically 90 to 110 feet below ground surface (bgs).

The aquifer zones are not hydraulically independent and groundwater can flow vertically between them. Horizontal groundwater movement in each zone is generally in a south-southwest direction, toward a regional pumping depression south of Sacramento. South and west of McClellan AFB numerous active private and public water supply wells influence the immediate subregional groundwater flow; therefore, groundwater flow directions on the base are dependent on location. The groundwater extraction systems installed at McClellan AFB during the 1980s also exert some local hydraulic control in the shallow aquifer zones. The groundwater gradient for the A-aquifer zone (shallowest zone) ranges from approximately 0.0014 ft/ft to 0.0025 ft/ft, based on water level results measured in January 1991 (Radian 1992).

Soils in the vicinity of the base are extremely variable, but are generally classified as fine, sandy loams. These soils have low shrink-swell potential and generally low soil permeabilities, varying locally.

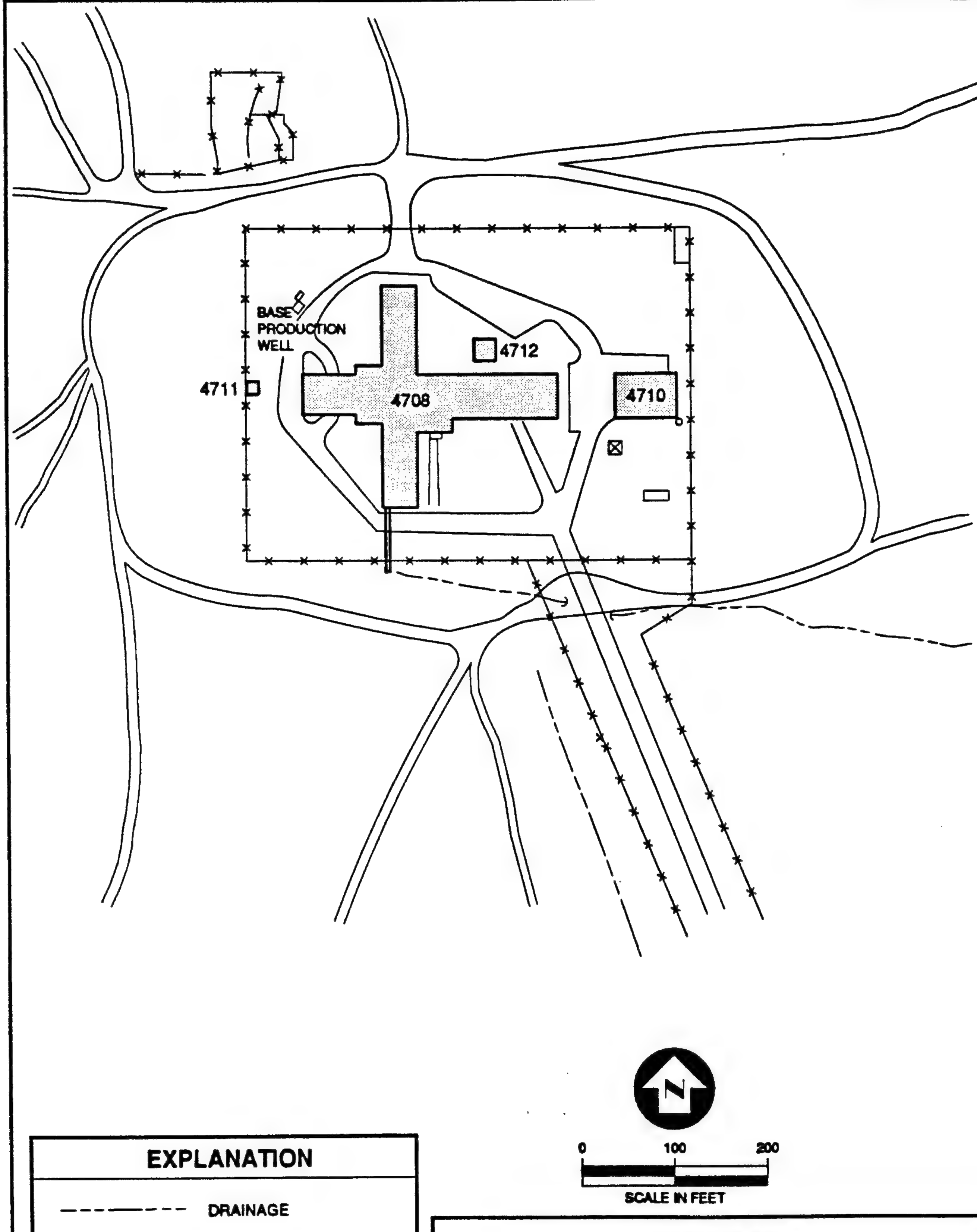
McClellan AFB and the surrounding Sacramento Valley have a Mediterranean-Subtropical climate characterized by hot, dry summers and cool, moist winters. Average temperatures range from the mid-40s during the winter months to the mid-70s during the summer months. Maximum daily summer temperatures often exceed 100°F, while winter temperatures rarely drop below 20°F. Most precipitation falls during the winter and spring months. Average annual rainfall is approximately 17 inches per year.

### 1.4 Davis Site Background

The Davis Global Communications Site (Davis Site) is located approximately 20 miles southwest of McClellan AFB in Davis, California and occupies approximately 316 acres in a predominantly agricultural area (Figure 1.3). The Davis Site serves as a communications annex for McClellan AFB and is manned 24 hours a day by up to 12 personnel of the 2049th Communication Squadron, which operates out of McClellan AFB. Operational facilities and controls are located within a fenced compound located near the center of the site. Outside the fenced area are more than two dozen antennae and transmitters.

Environmental investigations at the Davis site began as early as 1981 and the site is currently part of the USAF Installation Restoration Program (IRP). These investigations have involved leaking underground fuel storage tanks (UFSTs), site characterization,

FIGURE 1.3




## EXPLANATION

DRAINAGE

BUILDING

PROPOSED BIOVENTING PILOT TEST SITE

FENCE

SOURCE: Modified from I T Corporation, 1992

# SITE MAP
# DAVIS GLOBAL COMMUNICATIONS SITE

## DAVIS, CALIFORNIA

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soil-gas surveys, cone penetrometer surveys, soil sampling, and groundwater monitoring. Chlorinated volatile organic compounds (VOCs) and petroleum products have been found in both groundwater and soil at the site.

### 1.5 Davis Site Geology and Environmental Setting

Because of its close proximity, the geology and climate of the Davis Site is very similar to that of McClellan AFB described in Section 1.3. Beneath the Davis Site are fluvial deposits of Quaternary clay, silt, sand and gravel. Seven sand units have been identified in the immediate area. These units are designated A through G, from shallowest to deepest. Unit A is thin and neither saturated nor continuous. The remaining units are saturated and have been defined as aquifers zones B through G. The horizontal hydraulic conductivity of these aquifers is high, which is expected with sand and gravel aquifers.

There are large seasonal fluctuations in groundwater levels at the site. In 1991, groundwater levels in the B-aquifer wells were measured and ranged from a minimum of approximately 34 feet bgs to a maximum of approximately 73 feet bgs (IT Corporation 1992). The drop in groundwater levels during the summer is attributed to the lack of infiltration recharge during the dry season and to increased pumping by local agricultural supply wells. Based on 1991 groundwater elevation data, groundwater flow in the B-aquifer is towards the west-southwest in the winter and toward the south in the summer. Groundwater gradients were calculated to be approximately 0.001 ft/ft during the winter months and approximately 0.007 ft/ft during summer months. The larger gradients during the summer are attributable to drawdown effects from the local pumping wells.

The surface soils which cover the Davis site range from well-drained to poorly-drained silty clay loams, depending on location. The permeability of these soils is low to moderately low, and runoff is very slow.

## 2.0 SITE DESCRIPTIONS

The following sections provide a brief summary of the location, history, geology, and known contaminant distribution at each of the six sites where bioventing pilot testing will occur.

Five of the six sites are located at McClellan AFB and the sixth site is located at the Davis Global Communications Site. At McClellan AFB, two of the sites are in OU A: Tank Farm #2 and Tank Farm #4 (Figure 2.1), two are in OU B: SA 6 and PRL T-46, and one is in OU C: Building 720 (Figure 2.2).

## 2.1 Tank Farm #2

### 2.1.1 Site Location and Description

Tank Farm #2 (also designated as Site T-16) is the former location of four UFSTs, one underground waste fuel storage tank, and two above ground storage tanks. The site is located northeast of Building 475A along the southeastern boundary of OU A (Figure 2.1 and Figure 2.3) and is currently an empty lot covered with surface gravel surrounded by a chain-link fence.

### 2.1.2 Site History

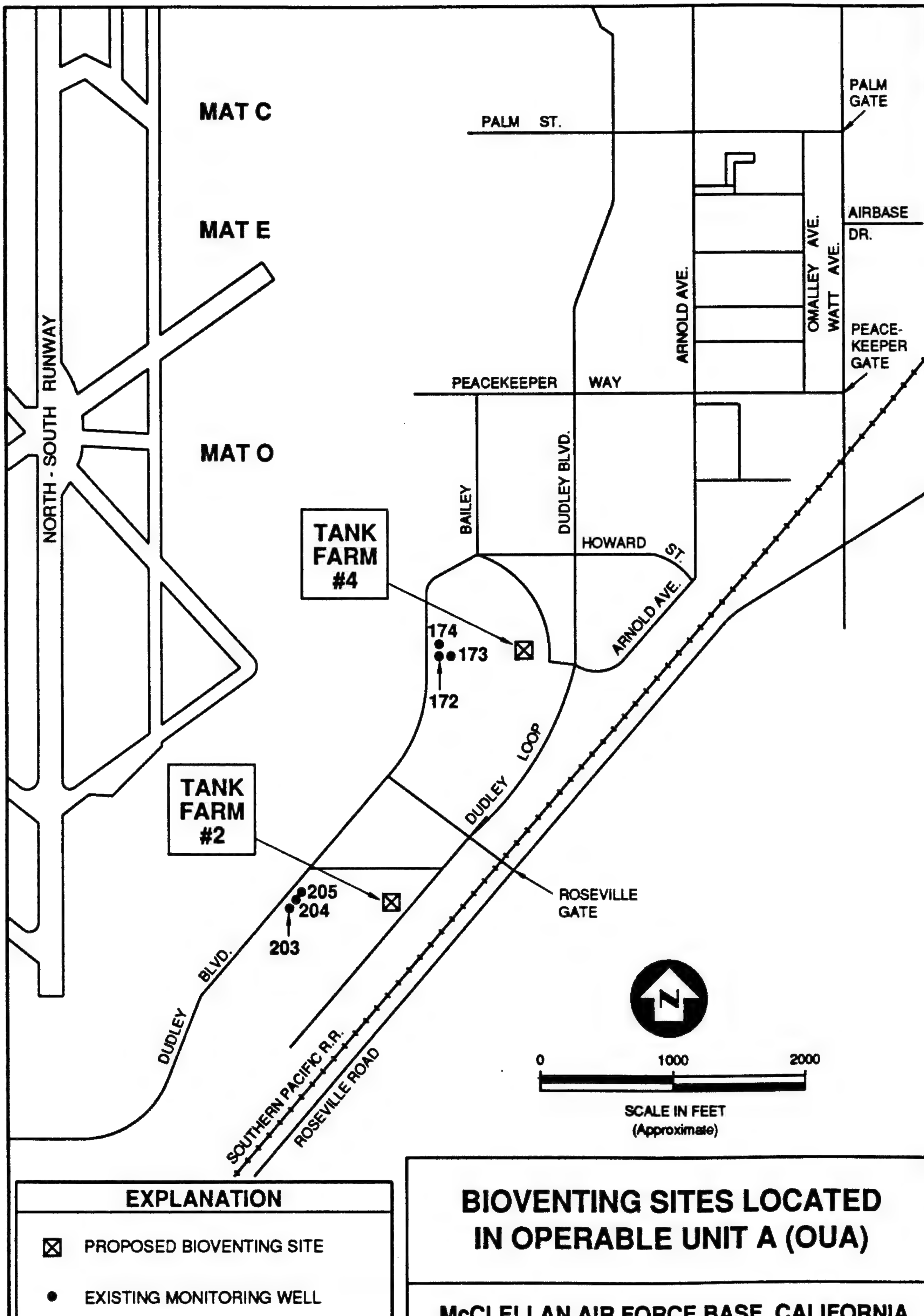
The four UFSTs, approximately 25,000-gallon capacity each, and the waste fuel tank, approximately 12,000-gallon capacity, were installed in 1938. The four UFSTs were used to store jet fuel (JP-4). Fuel was delivered to the site from rail cars and fuel spills are known to have occurred. An investigation was conducted in 1987 in which five soil borings were drilled around the perimeter of the tanks (Figure 2.3). Soil contamination was noted in four of the five borings (Jacobs Engineering 1992). The four UFSTs and the waste fuel tank were removed in August 1992; however, the contaminated soil which was excavated during tank removal was subsequently replaced in the excavation. The two above ground tanks are no longer on the site.

Other sources of potential contamination are located in the vicinity of Tank Farm #2. Building 475, to the southwest, is the site of an old reciprocating engine repair facility and contained paint and solvent spray booths, tanks, pits, and sumps. Between the 1940's and the mid-1960's, large quantities of carbon remover reportedly were used in the building. A solvent spray pool and industrial waste treatment area were located immediately north of the site and this area is currently used for scrap materials storage (McLaren Environmental 1986).

### 2.1.3 Site Geology

Because no detailed site investigation data was available, evaluation of the geology and hydrogeology of the site is based on base-wide mapping studies and soil borings drilled in the vicinity of the site.

Figure 2.4 is the boring log for soil boring SS7B01 drilled to approximately 95 feet bgs and located approximately 100 feet northwest of the site (see Figure 2.3). The soil profile encountered is interbedded sands and silts, each interval averaging about 5 feet in




SOURCE: Modified from McClellan AFB

**BIOVENTING SITES LOCATED IN OPERABLE UNIT A (OUA)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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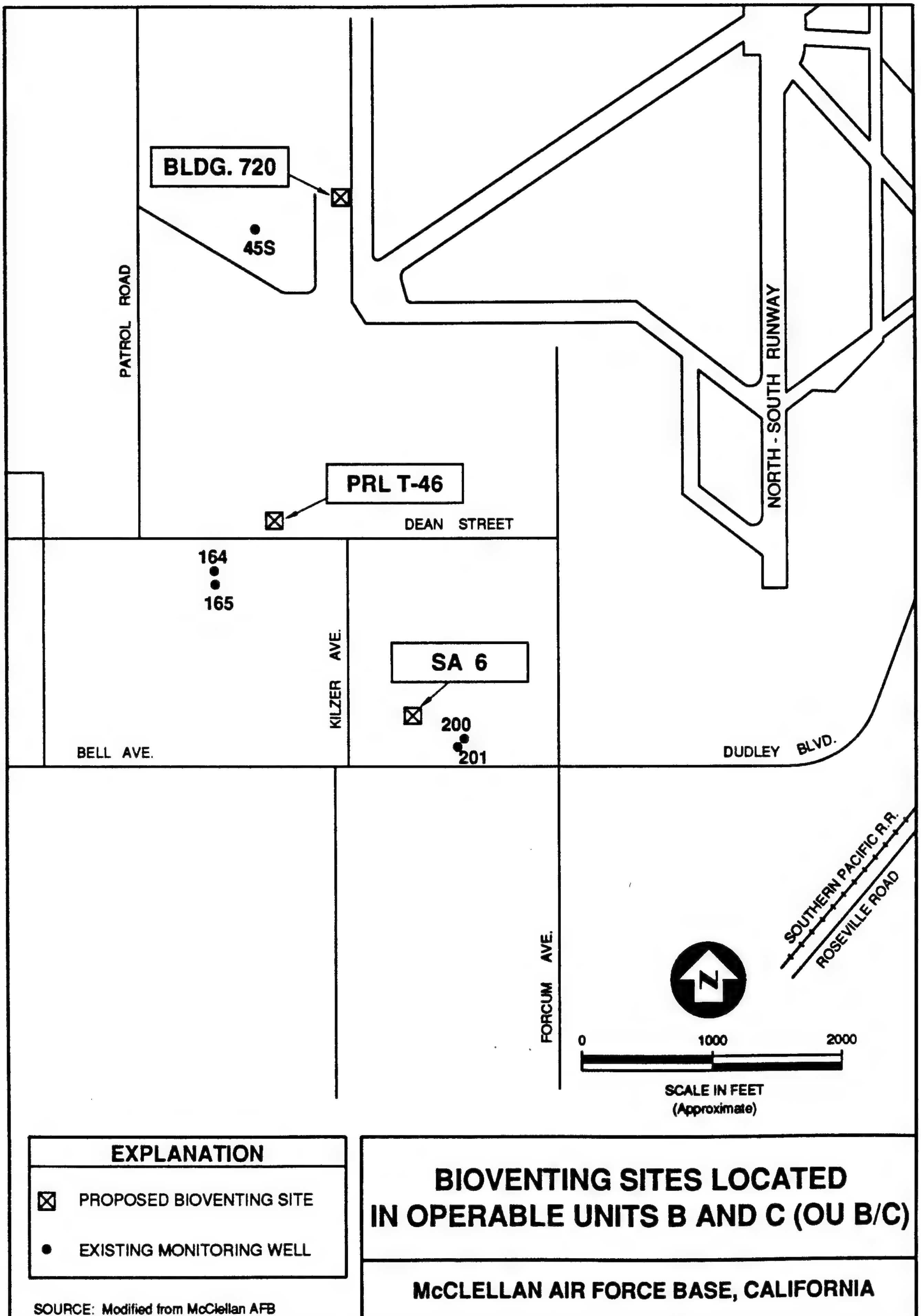
FIGURE 2.2




**BIOVENTING SITES LOCATED IN OPERABLE UNITS B AND C (OU B/C)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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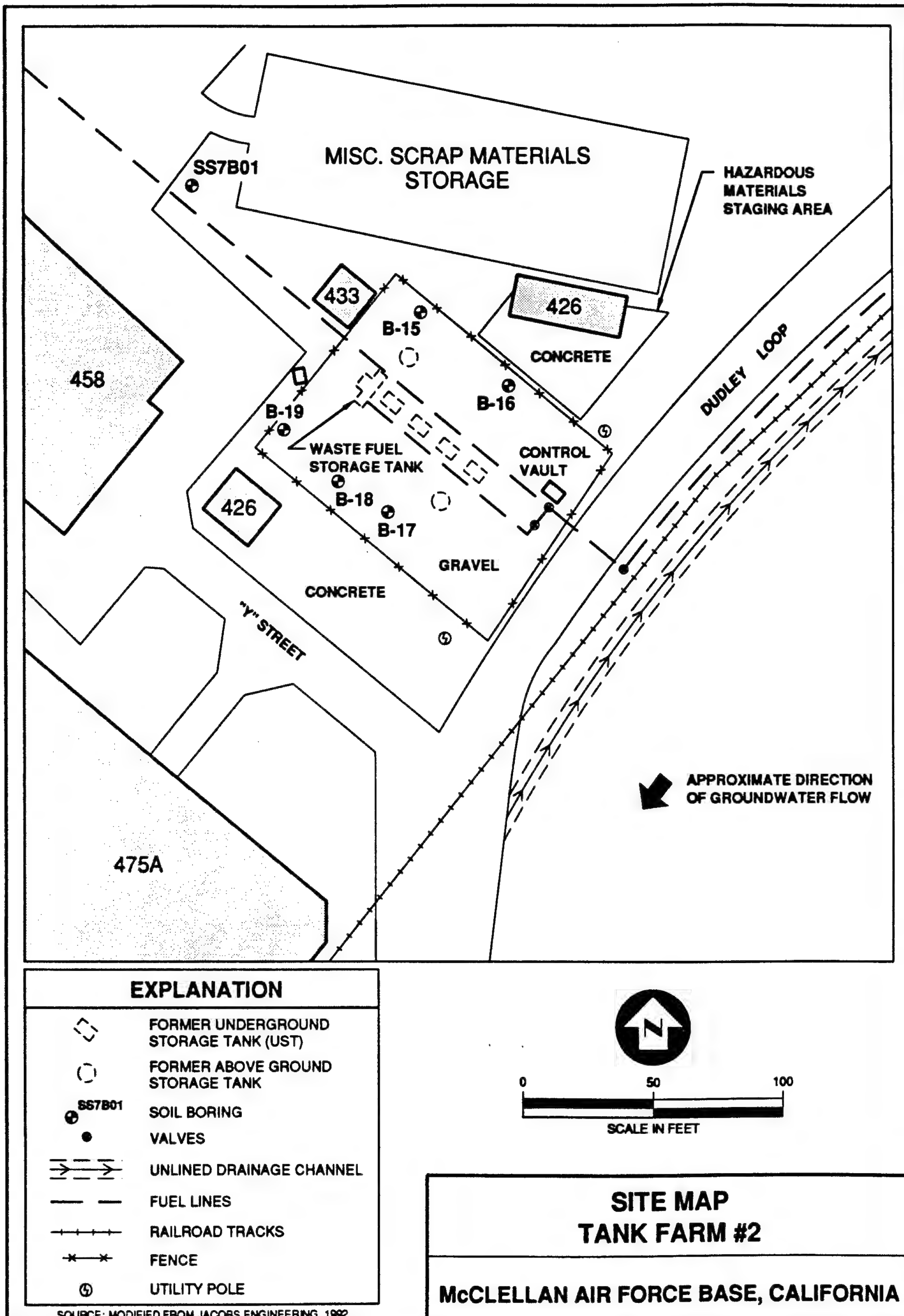
FIGURE 2.3




**SITE MAP**
**TANK FARM #2**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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**BORING NUMBER: SS7B01**

| | |
|---|---|
| **PROJECT NUMBER:** DE268.47.02 | **PROJECT NAME:** McClellan AFB Bioventing |
| **CLIENT:** McClellan Air Force Base | **DRILLER:** TRC |
| **LOCATION:** Tank Farm 2 | **DRILLING METHOD:** Air Percussion |
| | |
| **GEOLOGIST:** not reported | **HOLE DIAMETER:** 6 inches |
| **COMPLETION DATE:** 11 February 1993 | **TOTAL DEPTH:** 95.25 feet below ground surface |

| DEPTH feet | SAMPLE LOCATION | SAMPLE NUMBER | BLOW COUNT | PID (ppm) | GRAPHIC LOG | SOIL CLASS | GEOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SW | Coarse-grained SAND, olive (5Y4/3), moist, dense, nonplastic, minor HC odor |
| | | | | | | SP | Medium-grained SAND, olive (5Y4/3), moist, HC odor |
| 10 | | | | | | ML | SILT, olive gray to olive brown, moist to damp, medium dense, nonplastic, HC odor, some HC discoloration |
| | | | | | | SM | Silty SAND, olive (5Y5/3), medium dense, nonplastic, minor HC odor, very fine-grained sand |
| 20 | | | | | | ML | SILT, olive brown (2.5Y4/3), damp, medium dense, nonplastic, semi-cohesive, minor HC odor |
| 30 | | | | | | SP | Fine-grained SAND, light olive brown (2.5Y5/3), medium dense, nonplastic, minor HC odor |
| | | | | | | ML | Sandy SILT, olive (5Y4/3), very dense, nonplastic, medium-grained sand |
| 40 | | | | | | SP | Medium-grained SAND, light olive brown (2.5Y5/4), medium dense, nonplastic, minor HC odor |
| | | | | | | ML | Sandy SILT, dark yellowish-brown (10YR4/4), moist, dense, nonplastic, very fine-grained sand |
| 50 | | | | | | SP | Fine-grained SAND, olive brown (2.5Y5/4), medium dense, nonplastic, minor HC odor |
| | | | | | | SM | Silty SAND, dark grayish-brown (10YR4/2), dense, nonplastic, fine to medium-grained sand |
| 60 | | | | | | SP | Medium-grained SAND. dark yellowish-brown (10YR4/4), damp, very dense, nonplastic |
| | | | | | | ML | SILT, light olive brown (2.5Y5/3), dry to damp, very dense, nonplastic |
| 70 | | | | | | SP | Medium-grained SAND, olive gray (10Y4/2) to olive brown (2.5Y4/4), damp, dense, nonplastic |
| 80 | | | | | | ML | SILT, olive brown (2.5Y4/4), damp, very dense, nonplastic |
| 90 | | | | | | SP | Silty SAND, olive brown (2.5Y4/4), damp to moist, medium dense, nonplastic, fine-grained sand |
| | | | | | | CL | CLAY, light olive brown (2.5Y6/4), damp, hard, medium plasticity |
| 100 | | | | | | | Bottom of borehole |

▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

█ - Brass tube sample submitted for laboratory analysis.

Source: Modified from Jacobs Engineering (1993)

Mc01

thickness. Clay was encountered at the bottom of the borehole at approximately 90 feet bgs.

Similar soil profiles were encountered during drilling of monitoring wells MW-203, MW-204, and MW-205 located approximately 500 feet west of the site (Radian 1992).

Groundwater in the A-aquifer below the site is approximately 105 feet bgs based on water levels measured in October 1990 and January 1991 in MW-203 (Radian 1992). The groundwater flow is generally toward the southwest, based on groundwater levels taken during the same time period. The groundwater flow velocity was estimated at 0.54 ft/day (200 ft/yr) for MW-203 and the average hydraulic gradient is very gentle, approximately 0.0017 ft/ft. A downward vertical gradient of 0.0216 ft/ft was measured in January 1991 between MW-203, screened in the A-aquifer, and MW-204, screened in the B-aquifer.

### 2.1.4 Site Contaminants

Petroleum hydrocarbons and purgeable aromatics have been detected in soils at the site. During removal of the UFSTs in 1992, five soil samples were collected from the bottom of the excavation at 20 feet bgs and four soil samples were collected from the excavated soil pile (Figure 2.5). The excavated soil was subsequently placed back into the excavation. Table 2.1 shows the contaminant concentrations detected in soil samples from the bottom of the excavation, the excavated soil, and for soil boring B-18, which was advanced prior to UFST excavation during a previous investigation (EG&G INEL 1987).

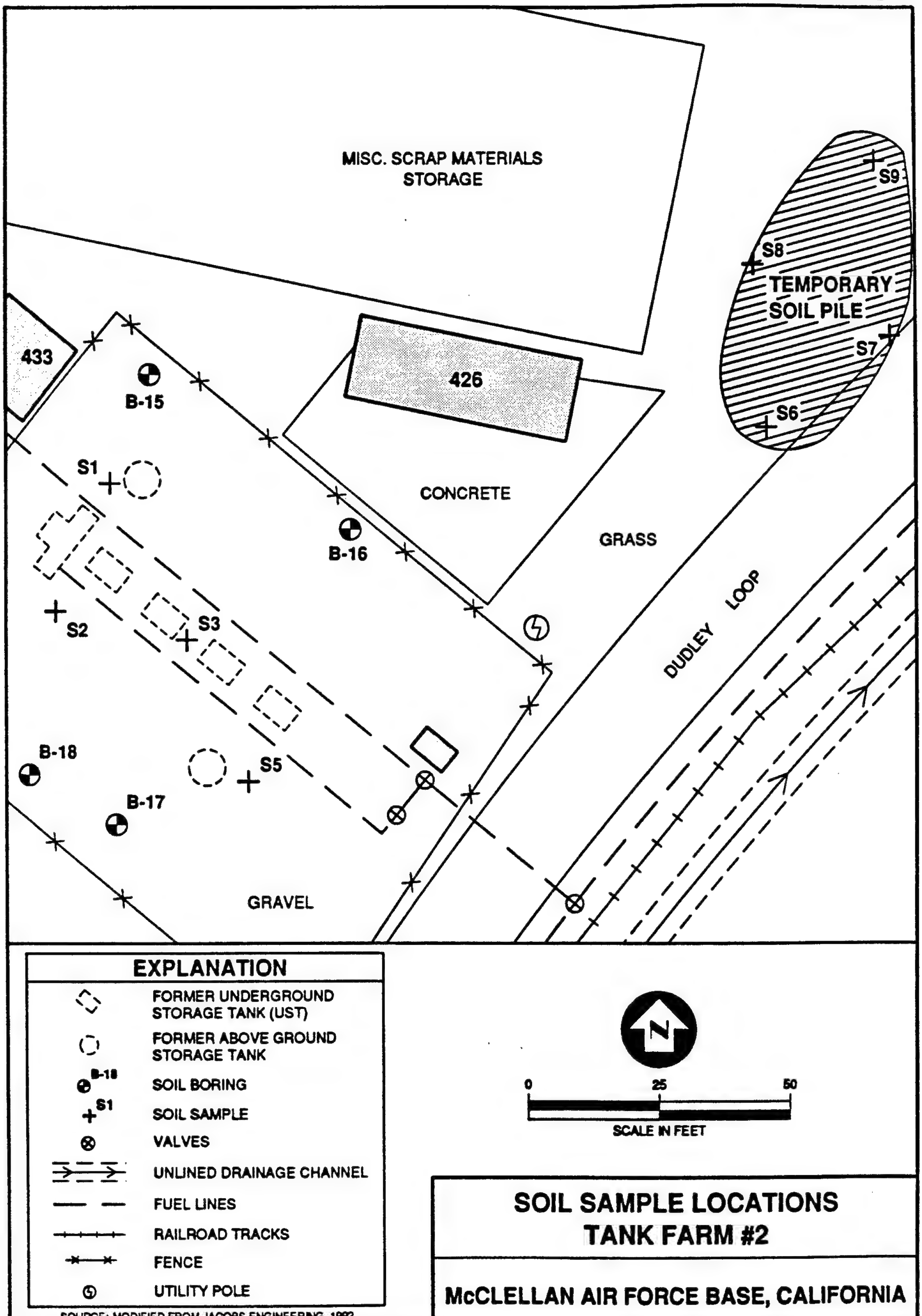
Soil samples from the excavation base, excavated soil, and soil borings were analyzed for total petroleum hydrocarbons (TPH) and purgeable aromatics including benzene, toluene, ethylbenzene, and total xylenes (BTEX). The maximum levels of contaminants found were 7,400 mg/kg TPH-g (B-18), 2,090 mg/kg TPH-JP5 (S3), 7,400 TPH-d (B-18), 205 mg/kg TPH-mo (S9), 0.251 mg/kg benzene (S3), 6.04 mg/kg toluene (B-18), 3.22 mg/kg ethylbenzene (S3), and 7.29 mg/kg total xylenes (S3). Soil sample S3 was collected from the immediate area of the tank pit and had the highest TPH and BTEX concentrations of all the samples collected from the base of the excavation. In addition to the contaminants listed in Table 2.1, chlorobenzene was detected at a maximum level of 0.61 mg/kg (B-18). It is not known how deep residual fuel contamination exists at the site since the deepest samples (20 to 24 feet bgs) had significantly high concentrations of fuel components.

## 2.2 Tank Farm #4

### 2.2.1 Site Location and Description

Tank Farm #4 (also designated as PRL T-18) is the former location of a truck filling stand, fuel receiving area, and four UFSTs. The site is located east of Building 343 within OU A (Figure 2.6). The site is currently a paved (asphalt) parking area.

FIGURE 2.5




**SOIL SAMPLE LOCATIONS**
**TANK FARM #2**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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# Table 2.1
# Soil Contaminant Concentrations at Tank Farm #2 McClellan AFB, California

| | | Total Petroleum HC | | | | Purgeable Aromatics | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method: | 8015 (modified) | | | | 8020 | | | |
| | Analyte: | TPH-g | TPH-JP5 | TPH-d | TPH-mo | Benzene | Toluene | Ethylbenzene | Total Xylenes |
| Location | Depth (ft bgs) | concentrations in mg/kg | | | | | | | |
| B-18* | 19, 24** | 7,400 | n.r. | 7,400 | n.r. | 0.089 | 6.04 | 0.26 | 33 |
| S1 | 20 | 268 | <5 | <10 | <25 | 0.117 | 0.078 | 0.574 | 4.09 |
| S2 | 20 | 844 | <5 | <10 | <25 | 0.039 | 0.129 | 2.08 | 3.57 |
| S3 | 20 | <50 | 2,090 | <100 | <250 | 0.251 | 0.207 | 3.22 | 7.29 |
| S4 | 20 | <5 | 407 | <10 | <25 | n.r. | n.r. | n.r. | n.r. |
| S5 | 20 | <5 | <5 | 22.7 | 51.1 | <0.001 | <0.001 | <0.001 | <0.001 |
| S6 | (excavated soil) | <5 | 33.8 | <10 | <25 | <0.0025 | <0.0025 | <0.0025 | <0.0025 |
| S7 | (excavated soil) | <5 | 1,350 | <10 | <25 | <0.025 | 0.219 | 0.617 | 2.55 |
| S8 | (excavated soil) | <5 | <5 | <10 | <25 | <0.001 | <0.001 | 0.009 | 0.022 |
| S9 | (excavated soil) | <5 | 675 | <10 | 205 | <0.025 | 0.387 | 1.56 | 5.25 |

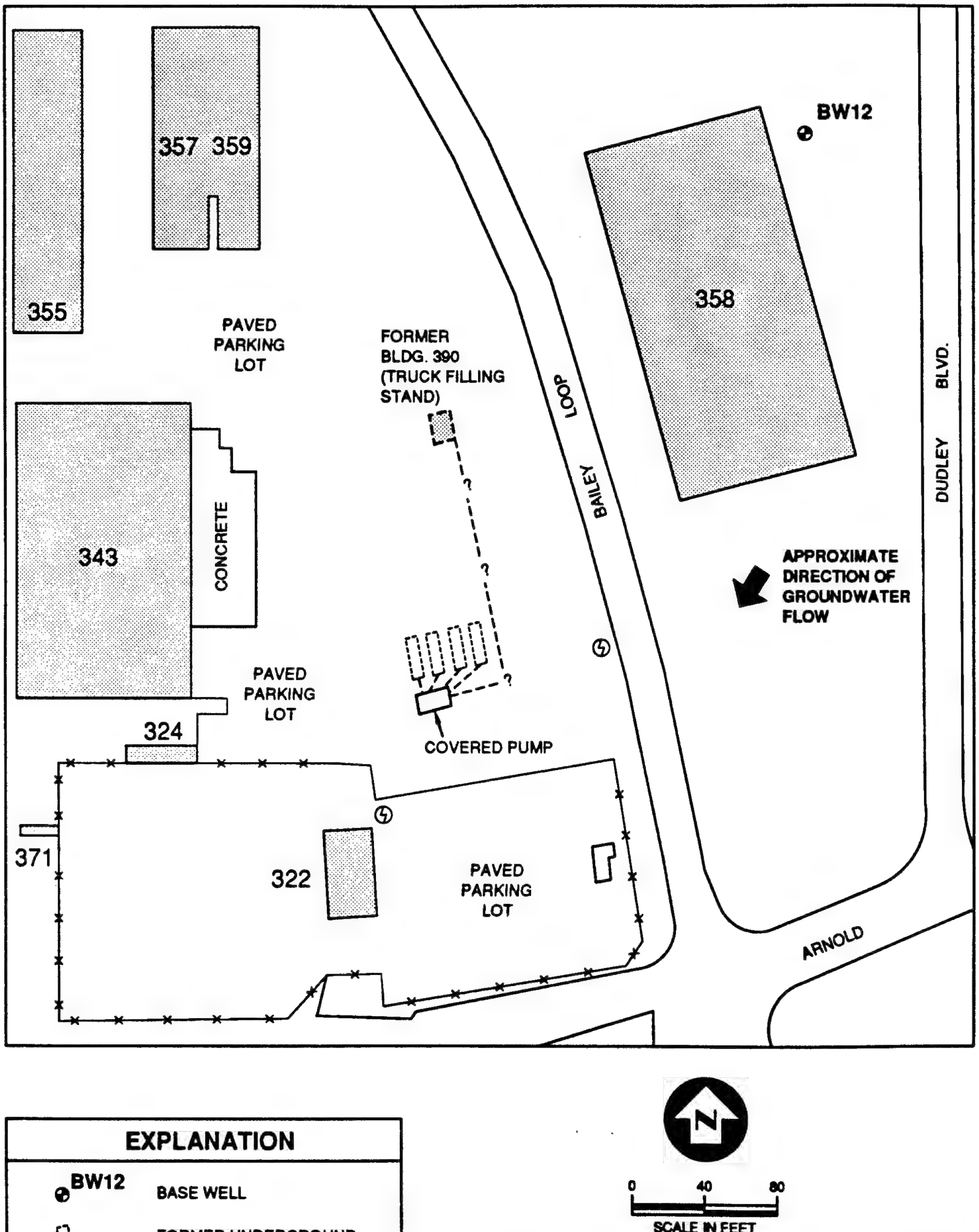
*LEGEND*

bgs : below ground surface
* : Only maximum concentrations reported.
** : Maximum concentration of ethylbenzene detected at 19 ft bgs. Maximum concentration of other contaminants detected at 24 ft bgs.
TPH-g : Total petroleum hydrocarbons as gasoline
TPH-JP5 : Total petroleum hydrocarbons as JP5
TPH-d : Total petroleum hydrocarbons as diesel
TPH-mo : Total petroleum hydrocarbons as motor oil
<10 : below given detection limit
n.r. : not reported

tf2_2_1
05/12/93

SOURCE: EG&G INEL (1987), McClellan AFB (1992)

FIGURE 2.6




**EXPLANATION**

| | |
|---|---|
| BW12 | BASE WELL |
| | FORMER UNDERGROUND STORAGE TANK (UST) |
| | FORMER FUEL LINES |
| | POWER POLE |
| | FENCE |

SOURCE: MODIFIED FROM RADIAN (1990)

**SITE MAP**
**TANK FARM #4**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 3 C257-10.DWG 01/13/94

ENGINEERING-SCIENCE, INC.

### 2.2.2 Site History

A 1940 aerial photograph shows evidence of the four UFSTs and the paved truck filling and receiving area. Each of the tanks had a capacity of approximately 25,000 gallons. In 1956, two of the tanks contained motor vehicle gasoline (MOGAS) and two contained jet fuel (JP-4). By 1976, all four tanks contained leaded regular gasoline. The site was identified as a potential source of contamination in 1986. By 1989, two tanks were no longer in use and the two remaining tanks were used for military unleaded premium gasoline (MUP gas). All four tanks were removed in May 1992 and contamination was noted in soil along the fuel distribution piping at the southern ends of the tanks. The contaminated soil which was excavated during tank removal was subsequently placed back in the excavation and the area was repaved as a parking lot.

### 2.2.3 Site Geology

Figure 2.7 shows the location of five shallow soil borings drilled in the area as part of a recent site investigation (Jacobs Engineering 1993). Figure 2.8 shows geologic cross-section A-A', constructed from these soil boring logs, and generally follows a south to north direction though the site. Clay and clayey sand units occur from ground surface to depths of 8 to 10 feet bgs. Sandy silt, silty sand and sand units predominate from the base of clay/sandy clay to at least 21.5 feet bgs, the depth at which the borings were terminated. Lithologic units are generally 3 to 9 feet in thickness.

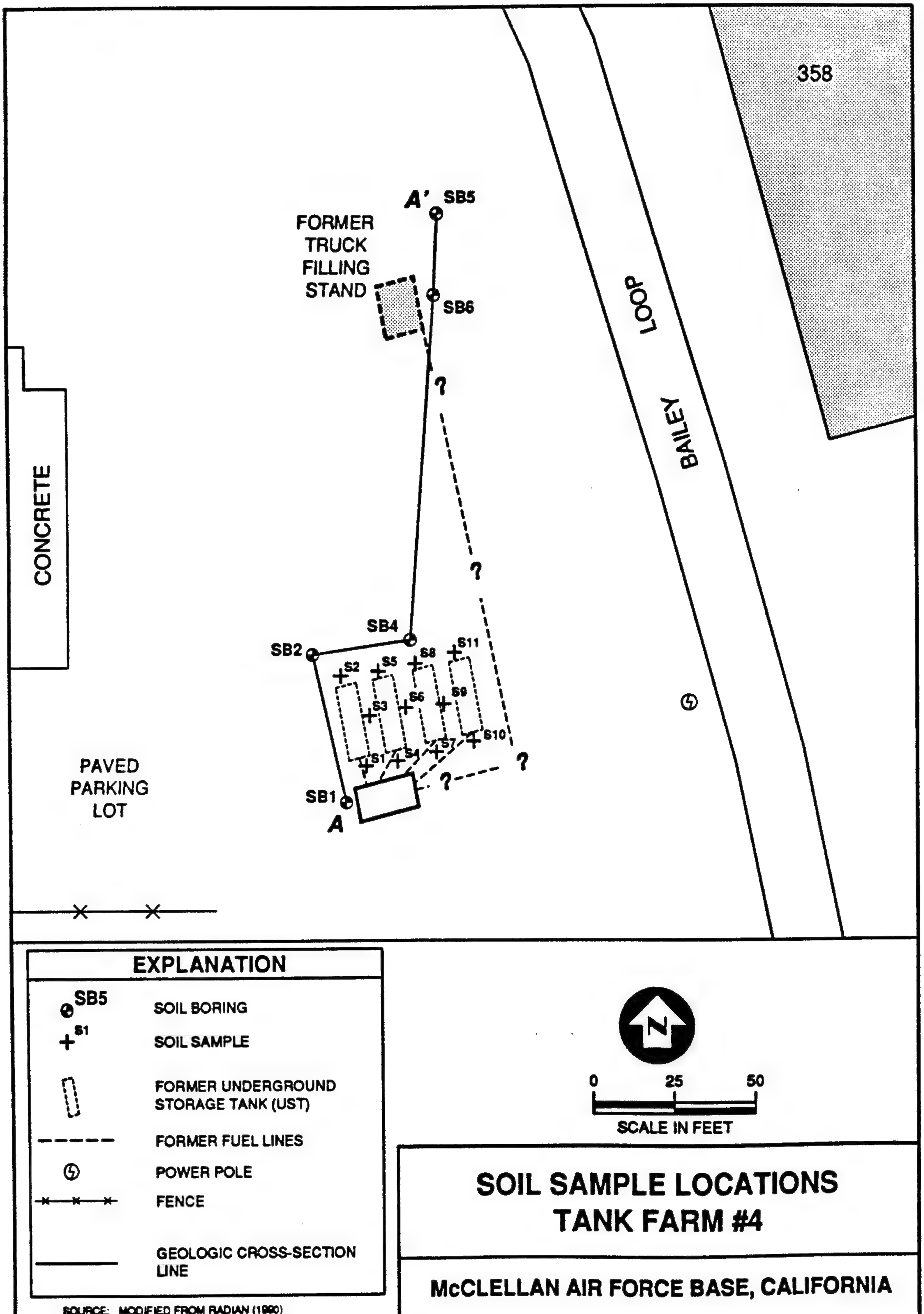
Groundwater in the A-aquifer below the site is approximately 110 feet bgs based on water levels measured in October 1990 and January 1991 in MW-172 (Figure 2.1), which is located approximately 500 feet west of the site (Radian 1992). The groundwater flow is generally toward the southwest, based on groundwater levels taken during the same time period. The groundwater flow velocity was estimated at 0.24 ft/day (88 ft/yr) for MW-172 and the average hydraulic gradient is very gentle, approximately 0.0013 ft/ft. A downward vertical gradient of 0.0280 ft/ft was measured in October 1990 between MW-172, screened in the A-aquifer, and MW-173, screened in the B-aquifer.

### 2.2.4 Site Contaminants

Petroleum hydrocarbons and purgeable aromatics have been detected in soils at the site. During tank removal operations in May 1992, eleven soil samples were collected from the bottom of the approximately 30 foot excavation. Sample locations are shown on Figure 2.7 and Table 2.2 shows the contaminant concentrations detected. Soil sample results from the soil borings were not available. It is not known if any soil samples were taken from the excavated soil before placement back into the excavation.

Soil samples from the excavation bottom were analyzed for total petroleum hydrocarbons (TPH), purgeable aromatics including benzene, toluene, ethylbenzene, and total xylenes (BTEX), and purgeable halocarbons. The maximum levels of contaminants found were 3,470 mg/kg TPH-JP5, 4.57 mg/kg toluene, 7.25 mg/kg ethylbenzene, and 61.6 mg/kg total xylenes. These maximum levels were all found at sample location S1, near the fuel distribution system piping. With the exception of location S2, all of the detected contamination was from samples collected at the south end of the UFSTs near

FIGURE 2.7




REV. 2 C257-11.DWG 05/12/93

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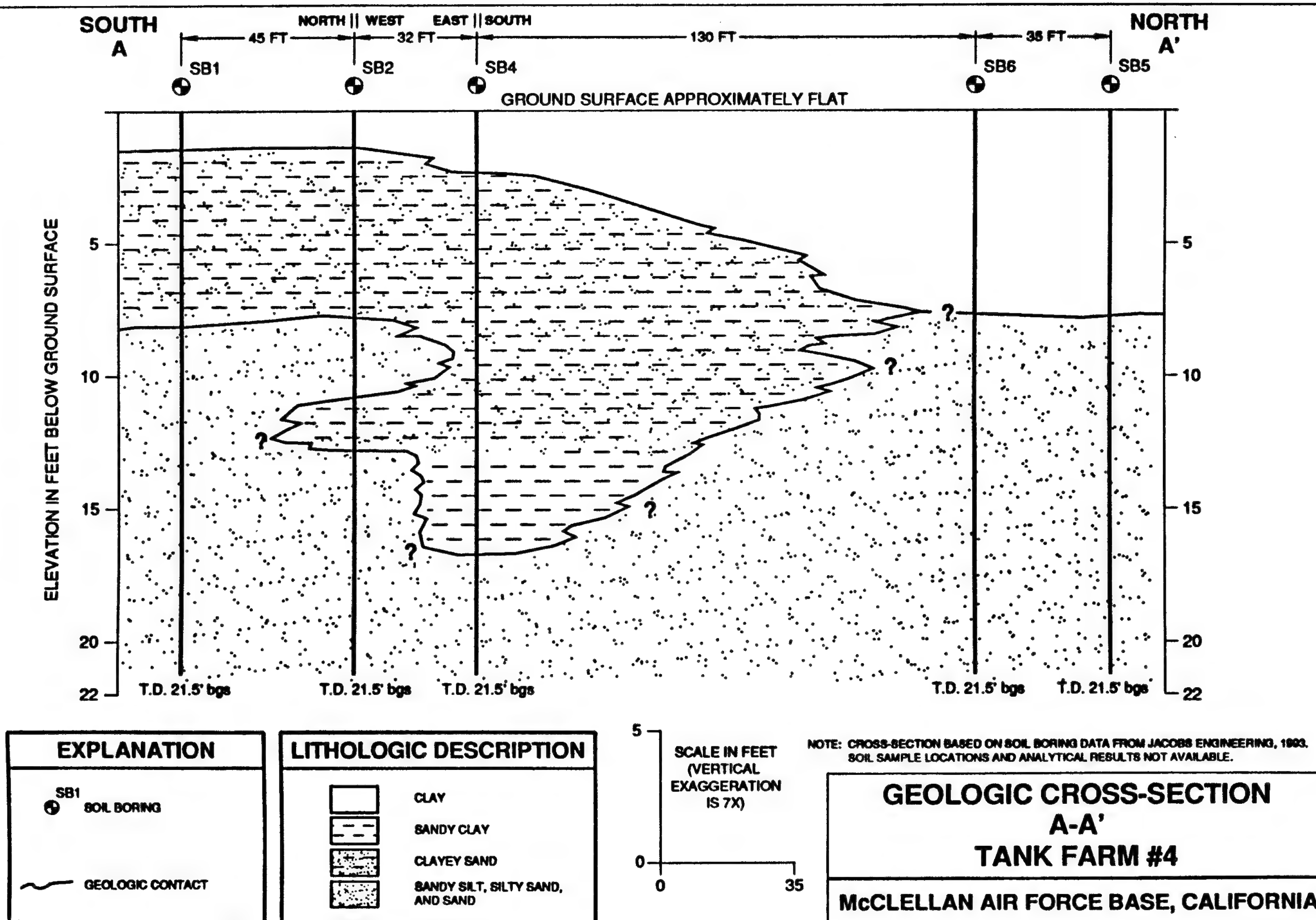



NOTE: CROSS-SECTION BASED ON SOIL BORING DATA FROM JACOBS ENGINEERING, 1993. SOIL SAMPLE LOCATIONS AND ANALYTICAL RESULTS NOT AVAILABLE.

FIGURE 2.8

# GEOLOGIC CROSS-SECTION A-A' TANK FARM #4

McCLELLAN AIR FORCE BASE, CALIFORNIA

REV. 2 C257-12.DWG 05/12/93

ENGINEERING-SCIENCE, INC.

## Table 2.2
## Soil Contaminant Concentrations at Tank Farm #4 McClellan AFB, California

| | | Total Petroleum HC | | | Purgeable Aromatics | | | | Purgeable Halocarbons |
|---|---|---|---|---|---|---|---|---|---|
| | Method: | 8015 (modified) | | | 8020 | | | | 8010 |
| | Analyte: | TPH-JP5 | TPH-d | TPH-mo | Benzene | Toluene | Ethylbenzene | Total Xylenes | 1,1,1-Trichloroethane |
| Location | Depth (ft bgs)* | concentrations in mg/kg | | | | | | | |
| S1 | 30 | 3,470 | <20 | <50 | <0.050 | 4.57 | 7.25 | 61.6 | <0.050 |
| S2 | 30 | <10 | <20 | <50 | <0.001 | 0.018 | 0.005 | 0.015 | <0.001 |
| S3 | 30 | <5 | <10 | <25 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| S4 | 30 | <5 | <10 | <25 | <0.050 | 0.070 | 0.18 | 0.28 | 1.0 |
| S5 | 30 | <5 | <10 | <25 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| S6 | 30 | <10 | <20 | <50 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| S7 | 30 | 907 | <20 | <50 | <0.050 | 0.123 | 0.193 | 1.85 | <0.050 |
| S8 | 30 | <10 | <20 | <50 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| S9 | 30 | <10 | <20 | <50 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| S10 | 30 | <10 | <20 | <50 | <0.005 | 0.017 | 0.025 | 0.192 | <0.005 |
| S11 | 30 | <10 | <20 | <50 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

*LEGEND*

- * : Samples collected from bottom of excavation; depth is estimated
- TPH-JP5 : Total petroleum hydrocarbons as JP5
- TPH-d : Total petroleum hydrocarbons as diesel
- TPH-mo : Total petroleum hydrocarbons as motor oil
- <10 (shaded) : below given detection limit

SOURCE: McClellan AFB, 1992

tf4_2_2
04/27/93

the fuel distribution system piping, where contamination was also visibly observed during tank removal operations. A concentration of 1.0 mg/kg 1,1,1-trichloroethane was detected at sample location S4.

The lack of detectable levels of TPH contamination throughout the site may be attributable to the analytical method chosen for the soil samples. Gasoline is known to have been stored in the tanks in recent years at this site.

## 2.3 SA 6

### 2.3.1 Site Location and Description

Study Area 6 (SA 6) is located in the southwestern corner of the base within OU B, midway between Buildings 655 and 652 (Figure 2.9). The site is the former location of a gasoline service station. The site is currently near the center of a large, paved parking lot which serves those buildings.

### 2.3.2 Site History

The former service station operated from 1955 until 1990. Two gasoline UFSTs and two diesel UFSTs which supplied the station were removed in 1990 and 1991, respectively. Initial investigations conducted by the base determined that the UFSTs had leaked and contaminated the soil. Subsequent investigations have more fully characterized the extent of the contamination.

During drilling operations conducted in February 1993, two soil borings were converted to vent wells (VWs) and two soil borings were converted to vapor monitoring points (VMPs) in anticipation of bioventing at the site (see Figure 2.10). The designation used for these vapor monitoring points at SA 6 was VPN (vapor piezometer nest), following naming protocol established by Radian Corporation. Despite its designation, VW-7 was constructed as a vapor monitoring point. Preliminary results from this field work have been used as reference for the discussions of site geology and site contaminants (Radian 1993a) which follow.

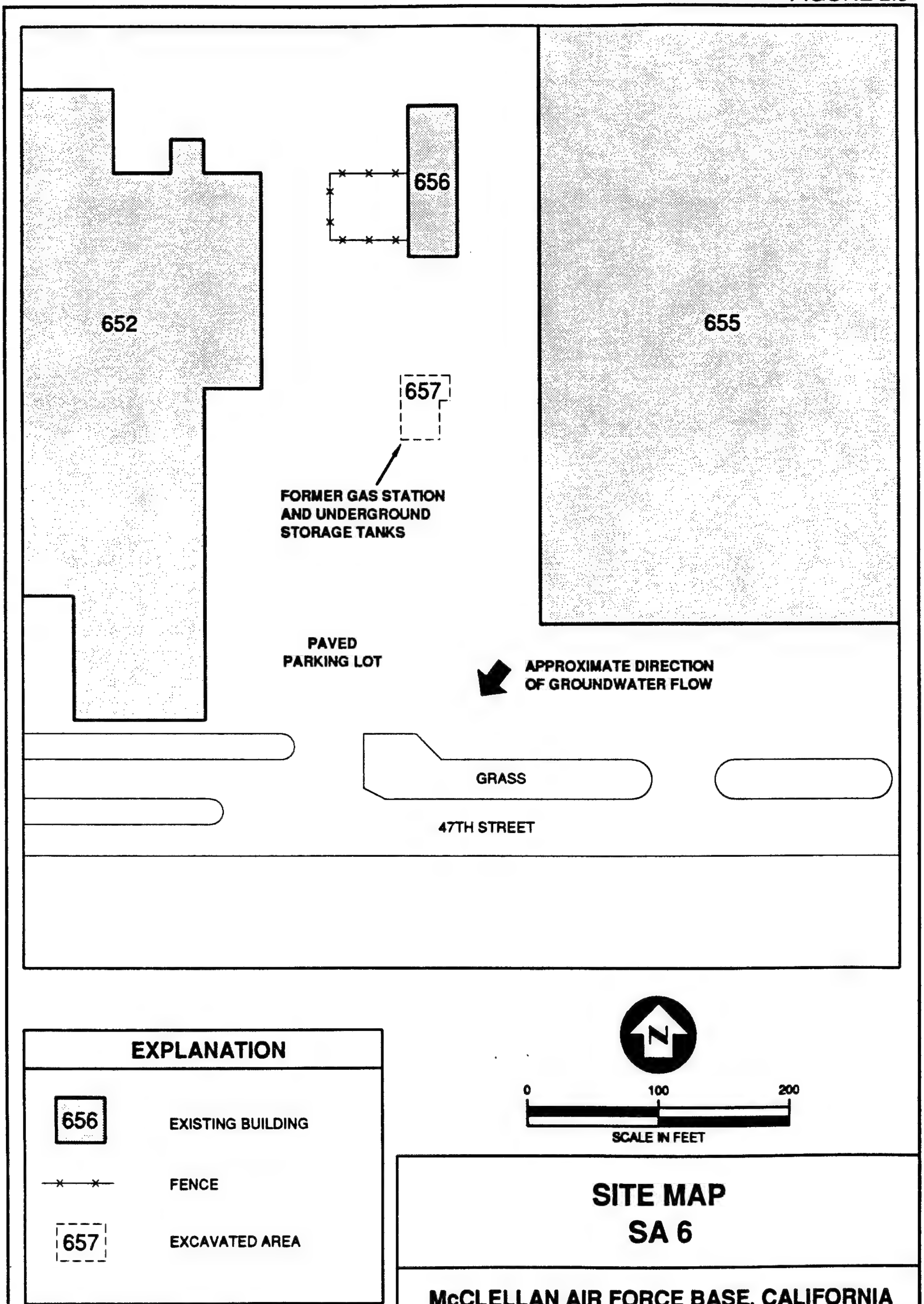
### 2.3.3 Site Geology

Figure 2.11 is geologic cross-section B-B' constructed from field boring logs for vapor monitoring points VPN-16 and VW-7, and vent wells VW-18 and VW-19. The cross-section is oriented along a generally north to south line through the site and exhibits a soil profile from the surface to 100 feet bgs.

The soils from ground surface to approximately 50 feet bgs consist predominantly of sands and silty sands with occasional interbedded silt layers. From approximately 50 feet bgs through 100 feet bgs, the soils are mainly silts with interbedded sand layers; however, at VW-18, sandy soils are predominant from ground surface to 80 feet bgs. These results are consistent with those from soil borings B5, B6, and B23. Field logs indicate that the site soils are moist at most depths and locations.

Evaluation of the hydrogeology of the site is based on base-wide groundwater elevation maps and information from monitoring wells MW-200 and MW-201, located approximately 500 feet southeast of the site (Figure 2.2). Groundwater in the A-aquifer

FIGURE 2.9




SOURCE: MODIFIED FROM RADIAN (1992).

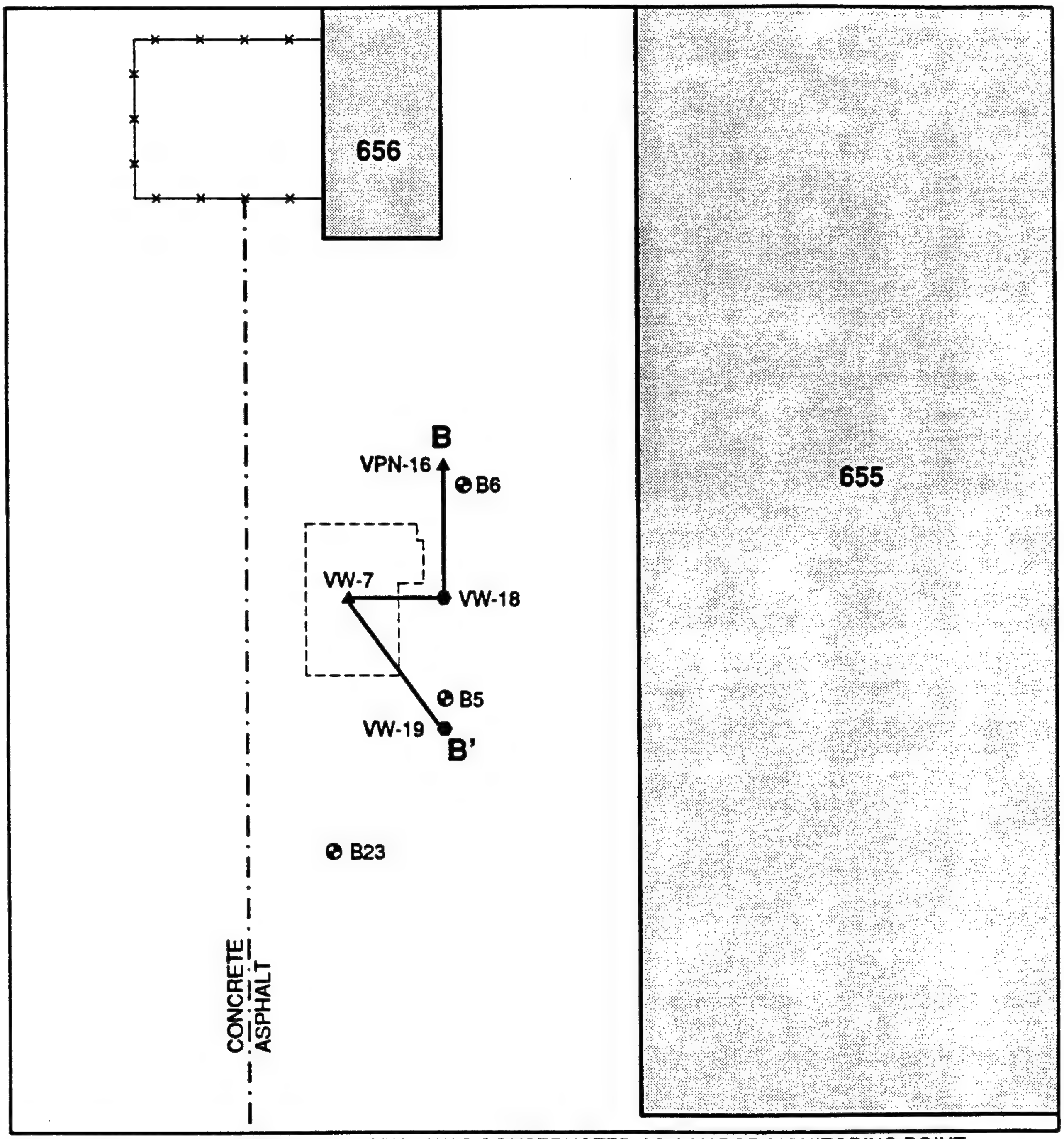
**SITE MAP**
**SA 6**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

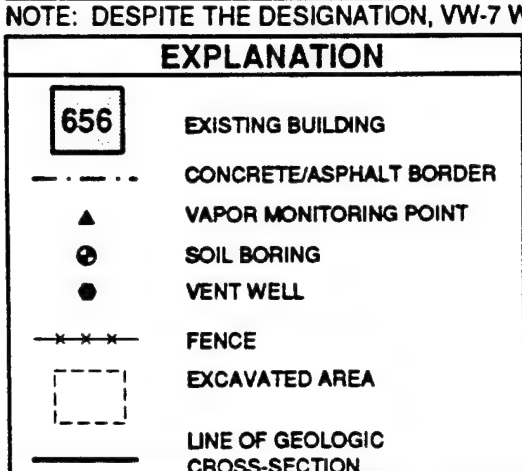
REV. 2 C250-05.DWG 05/12/93

ENGINEERING-SCIENCE, INC.

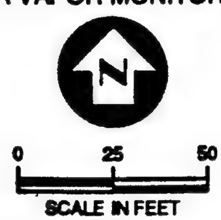
FIGURE 2.10




NOTE: DESPITE THE DESIGNATION, VW-7 WAS CONSTRUCTED AS A VAPOR MONITORING POINT




SOURCE: MODIFIED FROM RADIAN (1993).

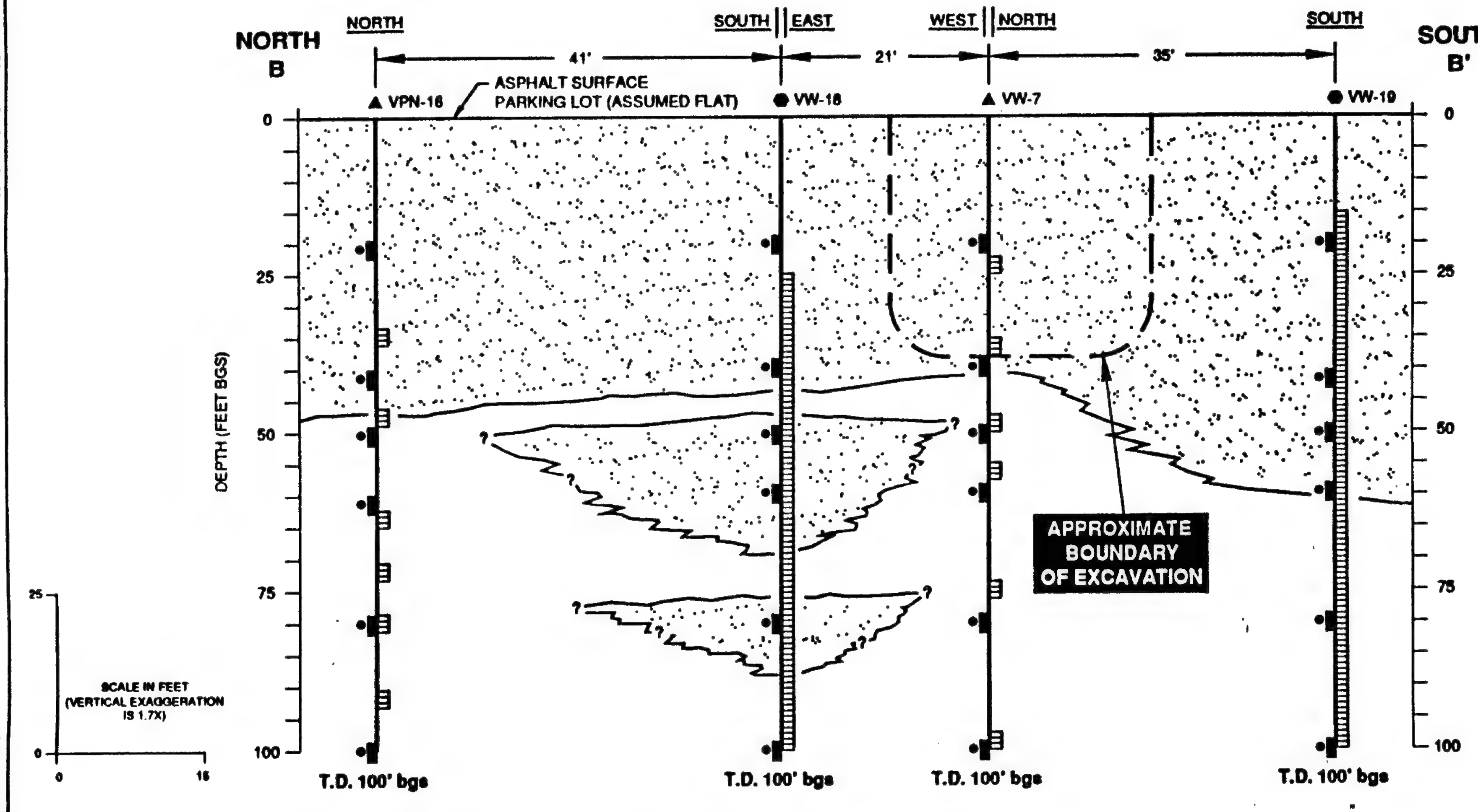



**SAMPLE AND WELL LOCATIONS**
**SA 6**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 2 C250-20.DWG 05/12/93

ENGINEERING-SCIENCE, INC.




NOTE: CROSS-SECTION DATA BASED ON SOIL BORINGS AND WELL CONSTRUCTION DATA FROM RADIAN (1993)

## EXPLANATION

- ▲ VAPOR MONITORING POINT
- ● VENT WELL
- •▮ SAMPLE INTERVAL (SOIL AND SOIL GAS; DOT INDICATES SAMPLES ANALYZED)
- ⊟ SCREENED INTERVAL

## LITHOLOGIC DESCRIPTION

- (stippled) PREDOMINANTLY SANDS, SILTY SANDS WITH SOME INTERBEDDED SILT LENSES
- (blank) PREDOMINANTLY SILTS WITH MINOR INTERBEDDED SAND LENSES

# GEOLOGIC CROSS-SECTION B-B'
## SA 6

McCLELLAN AIR FORCE BASE, CALIFORNIA

FIGURE 2.11

REV. 4 C254-05.DWG 05/20/93

ENGINEERING-SCIENCE, INC.

below the site is approximately 105 feet bgs based on water levels measured in October 1990 and January 1991 in MW-200 (Radian 1992). The groundwater flow is generally toward the southwest, based on groundwater levels taken during the same time period. The average hydraulic gradient is very gentle, approximately 0.002 ft/ft. Various aquifer pumping tests for the A-aquifer indicate widely varying groundwater flow velocities due to the varying thickness of local deposits. For pumping tests conducted in OU B, the groundwater flow velocity was on the order of 1 ft/day (360 ft/yr). A downward vertical gradient of 0.0102 ft/ft was measured in January 1991 between MW-200, screened in the A-aquifer, and MW-201, screened in the B-aquifer.

### 2.3.4 Site Contaminants

The contaminants documented in soil and soil gas at SA 6 include petroleum hydrocarbons, halogenated volatile organic compounds (HVOCs), aromatic volatile organic compounds (AVOCs), and semivolatile organic compounds (SVOCs). Table 2.3a presents available analytical data for soil samples collected between 0 and 100 feet bgs and Table 2.3b presents available analytical data for soil-gas samples collected between 20 and 100 feet bgs. Sample locations are shown in Figure 2.10. Hydrocarbon odors and staining were also noted in samples taken from several of the soil borings.

Soil samples were analyzed for volatile organic compounds (VOCs), including benzene, toluene, and total xylenes. The maximum levels found in the immediate vicinity of SA 6 were 22 mg/kg benzene, 300 mg/kg toluene, 570 mg/kg total xylenes, 0.039 mg/kg trichloroethene (TCE), and 0.0023 mg/kg tetrachloroethene (PCE). All maximum levels were found in soil boring B6 at approximately 35 feet bgs, which correlates to the lower part of the sandy interval as shown on the cross-section in Figure 2.11. Analytical results for soil samples taken during the recent drilling of VW-7, VW-18, VW-19, and VPN-16 are not yet available but will be included in the Interim Report, which will summarize results from the initial pilot tests.

The soil-gas results show the maximum contaminant levels reported by field gas chromatograph (GC) were >10,000 ppmv TPH, 8,320 ppmv total VOCs, 4,400 ppmv unknown VOCs, 1,200 ppmv benzene, 1,500 ppmv toluene, and 630 ppmv total xylenes. All maximum levels were found at VW-18. The following VOCs and SVOCs were also detected in varying concentrations in soil gas at borings in the vicinity of the site (Radian 1993b):

| | |
|---|---|
| carbon tetrachloride | tetrachloroethene (PCE) |
| chloroform | trans-1,2-dichloroethene |
| cyclohexane | 1,1,1-trichloroethane |
| 1,1-dichloroethene | trichloroethene (TCE) |
| dichlorodifluoromethane | vinyl chloride |
| Freon 113 | 1,2,4-trimethylbenzene |
| n-octane | 1,3,5-trimethylbenzene |

# Table 2.3a
# Soil Contaminant Concentrations at SA 6
# McClellan Air Force Base, California

| | | Petroleum HC | Aromatic Volatile Organic Compounds | | |
|---|---|---|---|---|---|
| | Method: | mod. 8015 | FVOC | | |
| | Analyte: | TPH | Benzene | Toluene | Total Xylenes |
| Location | Depth (ft bgs) | concentrations in mg/kg | | | |
| B5 | 10.3 | n.r. | 0.0022 | ND | ND |
| | 13.2 | n.r. | 0.0025 | ND | ND |
| | 15.5 | 2,600 | 14 | 22 | 55 |
| | 16.8 | n.r. | 0.035 | 0.073 | 0.13 |
| | 19.4 | n.r. | 0.030 | 0.028 | 0.083 |
| | 20.7 | n.r. | 0.015 | 0.0023 | 0.016 |
| | 23.3 | n.r. | 0.0063 | ND | 0.011 |
| | 33.2 | 14 | ND | ND | ND |
| | 35.4 | n.r. | 0.0036 | ND | ND |
| | 40.7 | n.r. | ND | ND | 0.0032 |
| B6 | 0 | n.r. | 0.44 | 0.83 | 0.65 |
| | 13.3 | n.r. | 0.048 | 0.24 | 2.2 |
| | 15.7 | 3,700 | 0.044 | ND | 0.0081 |
| | 19.2 | n.r. | ND | 1.6 | 28 |
| | 23.3 | 900 | 0.026 | ND | 0.056 |
| | 23.3 (dup)[1] | n.r. | 0.053 (0.009) | 0.073 (0.015) | 0.012 (0.030) |
| | 28 (dup) | n.r. | 7.5 (ND) | 70 (72) | 124 (210) |
| | 32.7 | 1,500 | 19 | 200 | 350 |
| | 35.4 | n.r. | 22 | 300 | 570 |
| | 40.9 | n.r. | 0.078 | 0.091 | 0.036 |
| | 46.9 | n.r. | 0.0068 | ND | ND |
| | 51.9 | n.r. | 0.020 | 0.0099 | 0.012 |
| | 61.0 | n.r. | 0.0078 | ND | 0.0036 |
| | 67.0 | n.r. | 0.0034 | ND | ND |
| | 87.0 | n.r. | 0.0027 | ND | ND |
| | 90.6 | n.r. | 0.0039 | ND | 0.0043 |
| | 96.0 | n.r. | 0.0052 | 0.0056 | 0.0081 |
| | 100.2 | n.r. | ND | 0.028 | 0.021 |
| B23 | 17.4 | n.r. | 0.0025 | ND | ND |

*LEGEND*

bgs : below ground surface
(dup) : duplicate sample results given in ()
[1] : duplicate sample results given in () analyzed by EPA 8240
TPH : Total petroleum hydrocarbons (extractable)
FVOC : Field volatile organic compound screening
ND : not detected; detection limit not reported
n.r. : not reported

sa6a
04/12/93

SOURCE: Radian Corporation, 1993b (preliminary results)

# Table 2.3b
# Soil Gas Contaminant Concentrations at SA 6
# McClellan Air Force Base, California

| | | Petroleum HC | Aromatic VOCs | | | Unknown VOCs |
|---|---|---|---|---|---|---|
| | Method: | field meter | FPID/EPA TO−14 | | | FPID |
| | Analyte: | TPH | Benzene | Toluene | Total Xylenes | −− |
| Location | Depth (ft bgs) | concentrations in ppmv | | | | |
| B5 | 21 (dup)[1] | n.r. | 21 (27) | ND (ND) | 46 (90) | 27 |
| | 42 | n.r. | 0.81 | 0.37 | 0.54 | 5.5 |
| B6 | 21 | n.r. | 200 | 190 | 290 | 160 |
| | 41 | n.r. | 680 | 890 | 170 | 1,630 |
| | 61 | n.r. | 10 | 3.4 | 2.0 | 440 |
| | 96 (dup) | n.r. | 4.0 (3.9) | 18 (17) | 26 (26) | 13 (14) |
| B23 | 21 | n.r. | ND | ND | ND | ND |
| VW−7 | 20 (dup)[1] | n.r. | 0.35 (0.10) | 0.42 (ND) | 0.59 (ND) | 0.51 |
| | 40 (dup)[1] | 160 | 0.78 (6.0) | 0.35 (0.36) | 2.7 (2.9) | 3.8 |
| | 50 | 59 | ND | ND | ND | ND |
| | 60 | 60 | ND | ND | ND | ND |
| | 80 | 180 | 0.84 | 0.092 | 0.36 | 0.40 |
| | 100 | 110 | 0.86 | ND | 0.20 | ND |
| VW−18 | 20 (dup)[1] | 1,900 | 1,200 (630) | 1,500 (1,400) | 630 (150) | 4,450 |
| | 40 | >10,000 | 640 | 450 | 320 | 1,100 |
| | 50 (dup)[1] | >10,000 | 310 (98) | 1,100 (610) | 540 (520) | 770 |
| | 60 | 150 | 21 | 14 | 24 | 66 |
| | 80 (dup)[1] | >10,000 | 210 (43) | 560 (190) | 320 (23.2) | 450 |
| | 100 | 90 | ND | ND | ND | ND |
| VW−19 | 20 (dup)[1] | >10,000 | 330 (38) | 630 (330) | 220 (110) | 710 |
| | 40 | 880 | 9.0 | 2.9 | 5.2 | 31 |
| | 50 | 810 | 4.6 | 5.0 | 8.5 | 11.5 |
| | 60 | 500 | 0.57 | 0.21 | 0.094 | 2.0 |
| | 82 (dup)[1] | 120 | 12 (6.6) | 4.0 (1.2) | 4.8 (2.5) | 26.3 |
| | 100 (dup)[1] | 245 | 53 (6.1) | 8.5 (ND) | 3.0 (ND) | 183 |
| VPN−16 | 21 | ND | ND | ND | ND | 1.8 |
| | 42 | 16 | 0.094 | ND | ND | ND |
| | 50 | 58 | ND | ND | ND | ND |
| | 60 | 16 | ND | 0.011 | 0.016 | ND |
| | 80 (dup)[1] | 2 | ND (0.0083) | ND (0.014) | ND (0.0093) | ND |
| | 100 | 125 | ND | ND | ND | ND |

*LEGEND*

bgs : below ground surface
FPID : field gas chromatograph (GC) with photoionization detector (PID)
TPH : total petroleum hydrocarbons
VOCs : volatile organic compounds

(dup) : duplicate results given in ()
1 : duplicate analyzed by EPA TO−14
ND : not detected; det. limit not reported
n.r. : not reported

SOURCE : Radian Corporation, 1992 (preliminary results)

sa6b
04/09/93

Soil borings B6 and VW-18, which reported the highest soil and soil-gas contaminant concentrations, are located immediately northeast and east of the former UFST location respectively. However, it is not determinable if this area has the highest level of soil contamination since soil sample analytical results from the recently drilled wells are not yet available.

The contamination appears to have impacted groundwater beneath the site. The contaminant levels found in a grab groundwater sample (Hydropunch®) collected from soil boring B6 and analyzed for purgeable halocarbons (EPA Method 8010) and purgeable aromatics (EPA Method 8020) were: 650 µg/L toluene, 130 µg/L ethylbenzene, 740 µg/L total xylenes, 180 µg/L TCE, 41 µg/L 1,2-dichlorobenzene, 240 µg/L 1,2-dichloroethene, 9.0 µg/L 1,2-dichloropropene, and 11 µg/L chloroform.

## 2.4 PRL T-46

### 2.4.1 Site Location and Description

Potential Release Location (PRL) T-46 is the former location of an underground oil/water separator tank located approximately 30 feet south of the existing above ground storage tanks between Hangars 764 and 765 (Figure 2.12). The site is located south of Maintenance Air Terminal K (MAT K) in the north central portion of OU B. Hangars 764 and 765 are used for fueling, defueling, and repair of aircraft. Drain lines were connected from these hangars and from a refueling slab on the south side of MAT K to the separator tank. The site has an asphalt surface cover.

### 2.4.2 Site History

The oil/water separator tank was installed sometime before 1968 and emptied in 1987. The 2,000 gallon tank received aircraft fuels (JP-4 and JP-5), 10/10 slushing oil, and wastewater discharged from Hangars 764 and 765. In 1986, the tank contents were analyzed and indicated the presence of petroleum hydrocarbons, semivolatile organic compounds, and metals.

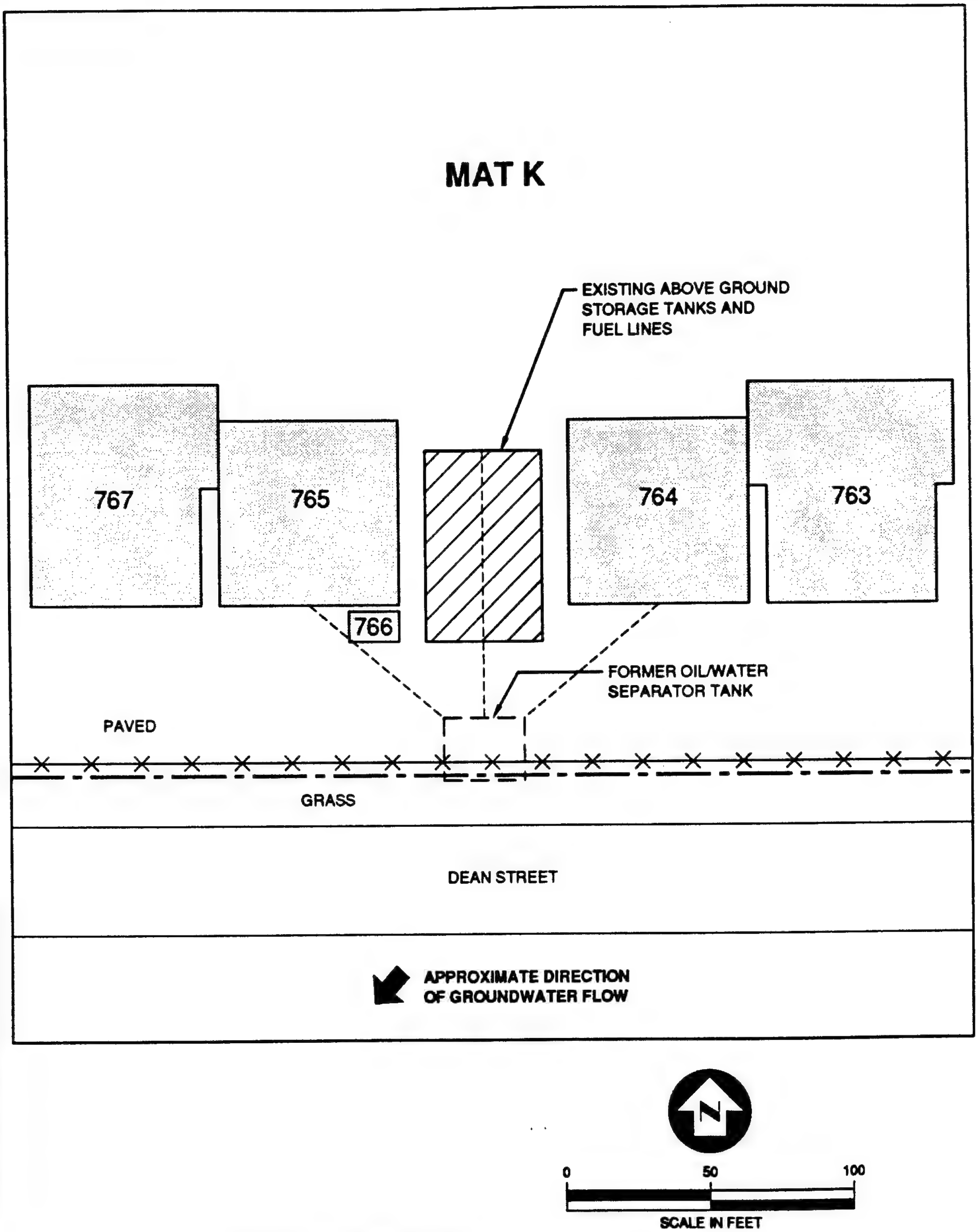
In November 1990, the tank was removed, and a pit 16 to 18 feet wide and 15 feet deep was excavated. During the removal, approximately 400 gallons of fuel and wastewater were spilled into the excavation pit. The excavation was backfilled with clean soil. In 1992, soil samples were collected from borings in the vicinity of PRL T-46 as part of an OU B remedial investigation (Radian 1993a).

### 2.4.3 Site Geology

Evaluation of the geology at PRL T-46 is based on soil borings recently drilled at the site and well logs of nearby groundwater monitoring wells. Evaluation of the hydrogeology of the site is based on base-wide groundwater elevation maps and information from monitoring wells MW-164 and MW-165, located approximately 700 feet southwest of the site (Figure 2.2).

Figure 2.13 shows the location of soil borings recently drilled at the site. Figure 2.14 is geologic cross-section C-C' constructed through four of the soil borings along a

FIGURE 2.12




## EXPLANATION

| | |
|---|---|
| — — — | IWL |
| —×—×— | FENCE |
| - - - - - - | FORMER DRAIN LINE |

SOURCE: MODIFIED FROM RADIAN (1993).

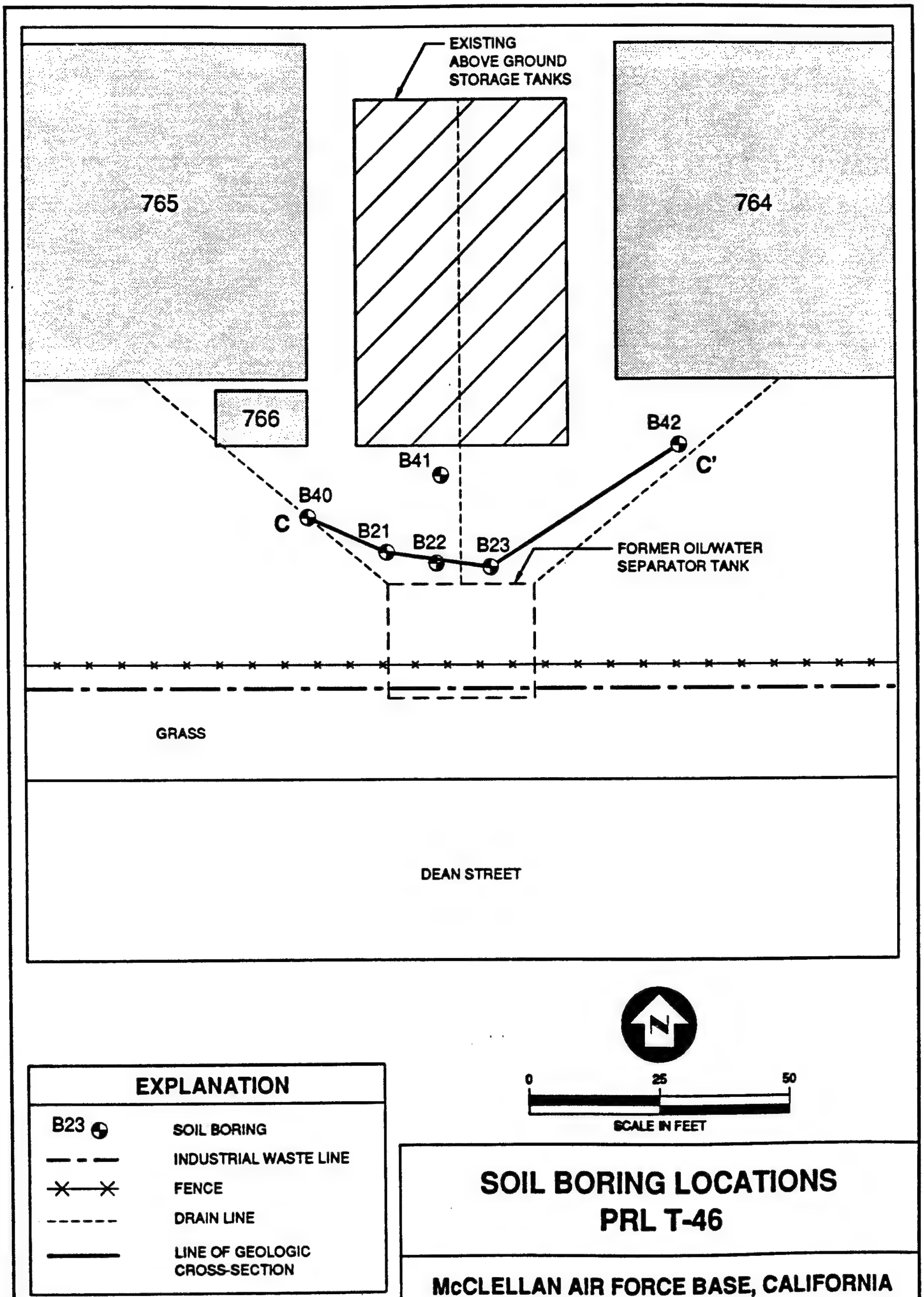
# SITE MAP
# PRL T-46

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 4 C250-03.DWG 01/13/94

ENGINEERING-SCIENCE, INC.

FIGURE 2.13



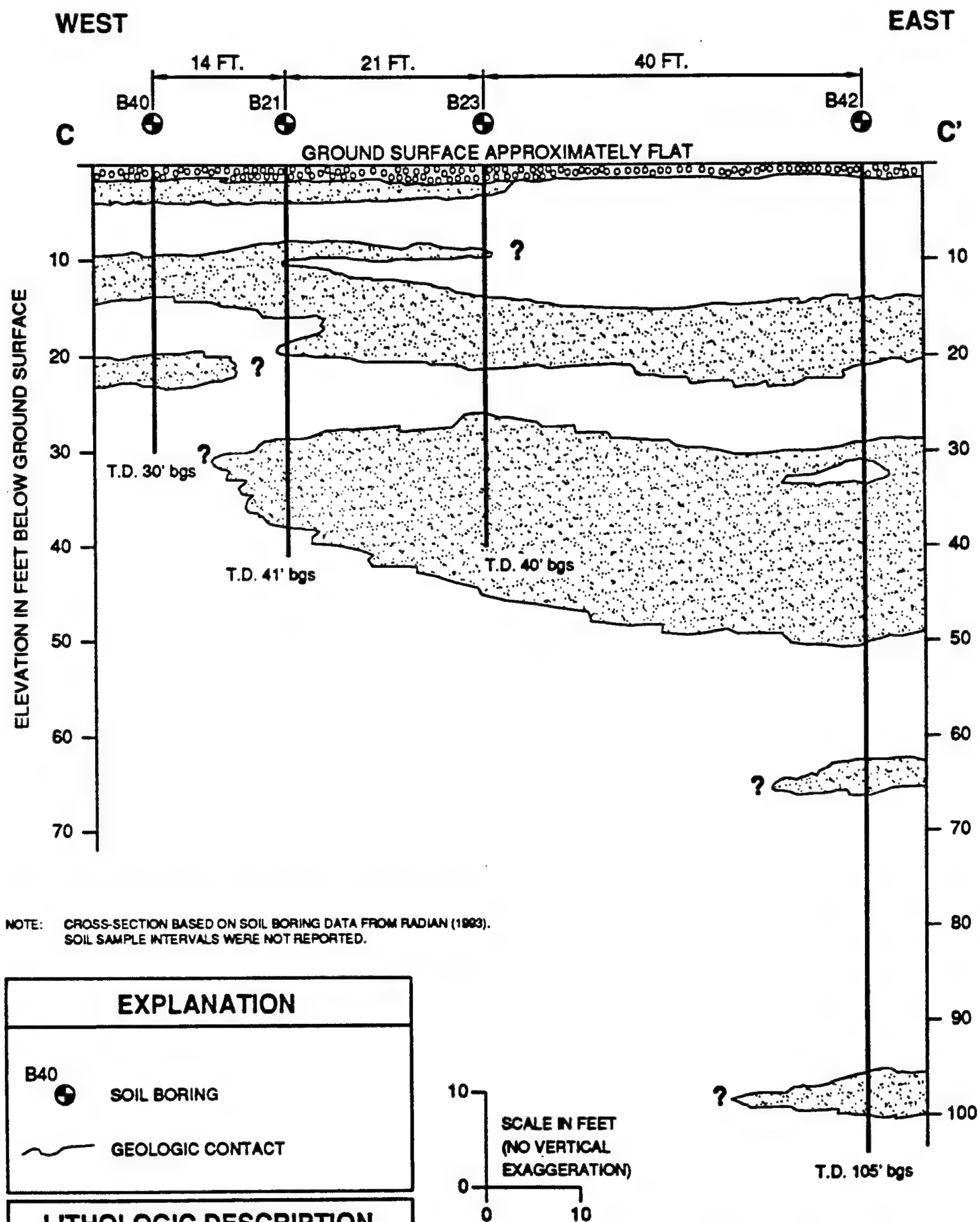

SOURCE: MODIFIED FROM RADIAN (1993).

# SOIL BORING LOCATIONS
# PRL T-46

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 2 C251-10.DWG 05/13/93

ENGINEERING-SCIENCE, INC.




NOTE: CROSS-SECTION BASED ON SOIL BORING DATA FROM RADIAN (1993). SOIL SAMPLE INTERVALS WERE NOT REPORTED.

## EXPLANATION

B40 SOIL BORING

GEOLOGIC CONTACT

## LITHOLOGIC DESCRIPTION

FILL

SAND, SILTY SAND, CLAYEY SAND

SILTS AND SILTY CLAYS

# GEOLOGIC CROSS-SECTION C-C'
# PRL T-46

## McCLELLAN AIR FORCE BASE, CALIFORNIA



ENGINEERING-SCIENCE, INC.

generally west to east line immediately north of the former tank location. The cross-section shows the soil profile from the surface to depths between 30 and 105 feet bgs.

The soils at the site from ground surface to 40 feet bgs are predominantly interbedded sands and silts, with some silty clays. Generally, the sands are silty sands and the silts are either sandy silts or clayey silts. In the deep boring (B42), soils below 50 feet bgs are predominantly silts with occasional sand intervals. Field logs indicate site soils are either damp or moist at all depths.

Groundwater in the A-aquifer below the site is approximately 104 feet bgs based on water levels measured in October 1990 and January 1991 in MW-164 (Radian 1992). The groundwater flow in this aquifer is generally toward the southwest based on groundwater levels maps for the same time period. Various aquifer pumping tests for the A-aquifer indicate widely varying groundwater flow velocities due to the varying thickness of local deposits. Based on aquifer pumping test data from OU B, the groundwater flow velocity is estimated to be on the order of 1 ft/day (360 ft/yr). The average hydraulic gradient is very gentle, approximately 0.002 ft/ft. A downward vertical gradient of 0.0082 ft/ft was measured between MW-164, screened in the A-aquifer, and MW-165, screened in the B-aquifer in January 1991.

### 2.4.4 Site Contaminants

The contaminants documented in soil and soil gas at PRL T-46 include petroleum hydrocarbons, halogenated volatile organic compounds (HVOCs), aromatic volatile organic compounds (AVOCs), and semivolatile organic compounds (SVOCs). Table 2.4a presents representative analytical data for soil samples, and Table 2.4b presents representative analytical data for soil-gas samples. Sample locations are shown in Figure 2.13. Hydrocarbon odors and visual evidence of contamination were also noted during soil borings.

Soil samples were analyzed for a range of contaminants, including extractable and purgeable total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, and total xylenes (BTEX), and SVOCs. The maximum levels found were 34,000 mg/kg extractable TPH (B21), 15,000 mg/kg purgeable TPH (B21), 20 mg/kg toluene (B22), 65 mg/kg ethylbenzene (B22), 150 mg/kg total xylenes (B22), 120 mg/kg 2-methylnaphthalene (B21), and 22 mg/kg bis (2-ethylhexyl) phthalate (B21).

The soil gas results show maximum contaminant levels reported by field GC/PID were 94 ppmv unknown VOCs, 1.4 ppmv benzene, 6.0 ppmv toluene, and 16 ppmv total xylenes (all at B21). One soil-gas sample from boring B21 was analyzed by EPA Method TO-14 and the following levels of contaminants were detected: 4.6 ppmv 1,3-butadiene, 7.9 ppmv cyclohexane, 15 ppmv propylene, and 0.47 ppmv n-octane. Results from analysis by field GC also indicated soil gas contaminated with low levels of various halogenated VOCs including trichloroethene (TCE), vinyl chloride, methylene chloride, and Freon 113 (Radian 1993b).

Maximum contamination in soil and soil-gas samples was reported for samples taken from borings B21 and B22. It is not known how deep residual contamination exists. No

# Table 2.4a
# Soil Contaminant Concentrations at PRL T-46
# McClellan Air Force Base, California

| | | Purgeable Petroleum HC | Extractable Petroleum HC | Purgeable Aromatics | | | |
|---|---|---|---|---|---|---|---|
| | Method: | 5030/8015 | 3550/8015 | 8020 | | | |
| | Analyte: | TPH | TPH | Benzene | Toluene | Ethylbenzene | Total Xylenes |
| Location | Depth (ft bgs) | concentrations in mg/kg | | | | | |
| B21 | 4.5 | 15,000 | 8,400 | ND | 19 | 42 | 70 |
| | 14.5 | 4,900 | 3,800 | n.r. | n.r. | n.r. | n.r. |
| | 22.8 | 2,300 | 34,000 | n.r. | n.r. | n.r. | n.r. |
| | 32.1 | 130 | 34 | n.r. | n.r. | n.r. | n.r. |
| B22 | 5.4 | 11,000 | 7,800 | ND | 20 | 65 | 150 |
| | 11.5 | 11,000 | 10,000 | ND | 11 | 16 | 19 |
| B23 | 2.2 | 8,200 | 2,100 | n.r. | n.r. | n.r. | n.r. |
| | 9.9 | 2,900 | 2,900 | n.r. | n.r. | n.r. | n.r. |
| | 19.0 | 270 | 140 | n.r. | n.r. | n.r. | n.r. |
| B40 | 10.1 | 720 | 4,700 | n.r. | n.r. | n.r. | n.r. |
| B41 | 4.0 | 4,000 | 4,000 | n.r. | n.r. | n.r. | n.r. |
| | 9.9 | 2,600 | 3,200 | ND | ND | 4.0 | 8.0 |
| | 18.2 | n.r. | 25 | n.r. | n.r. | n.r. | n.r. |
| B42 | 4.1 | 170 | 3,400 | n.r. | n.r. | n.r. | n.r. |
| | 10.1 | 0.7 | n.r. | n.r. | n.r. | n.r. | n.r. |

*LEGEND*

bgs : below ground surface
TPH : total petroleum hydrocarbons
ND : not detected; detection limit not reported
n.r. : not reported

prlt_46a
04/12/93

SOURCE: Radian Corporation, 1992

## Table 2.4b
## Soil Gas Contaminant Concentrations at
## PRL T-46
## McClellan Air Force Base, California

| | | Aromatic VOCs | | | Unknown VOCs |
|---|---|---|---|---|---|
| | Method: | FPID | | | FPID |
| | Analyte: | Benzene | Toluene | Total Xylenes | -- |
| Location | Depth (ft bgs) | concentrations in ppmv | | | |
| B21 | 21.0 | 1.3 | 3.1 | 4.9 | 48 |
| | 31.0 | 1.4 | 6.0 | 16 | 94 |
| | 41.0 | ND | ND | 0.053 | ND |
| B23 | 21.0 | 0.073 | ND | 1.66 | 6.5 |
| | 31.0 | ND | ND | 0.061 | ND |
| | 41.0 | ND | ND | 0.090 | ND |
| B41 | 21.0 | ND | ND | 4.6 | 56.1 |

*LEGEND*

bgs : below ground surface
FPID : field analysis by gas chromatograph (GC) with photoionization detector (PID)
VOCs : volatile organic compunds
ND : not detected (detection limit not reported)

prlt_46b

SOURCE: Radian Corporation, 1993b

04/12/93

analytical results were available for samples collected within the excavated area during tank removal operations.

## 2.5 Building 720

### 2.5.1 Site Location and Description

Building 720 is located between Hangars 721 and 722 west of MAT I (Figure 2.15). The site is in OU C and is not the subject of any current IRP investigation; however, an initial base-wide site assessment listed the site as Potential Release Location (PRL) S-48 (Radian 1990). The area of the proposed bioventing pilot test is grass covered and surrounding areas are paved with asphalt.

### 2.5.2 Site History

In March 1989, a geophysical survey and an exploratory excavation was performed by McClellan AFB personnel approximately 150 feet west of Building 720. This exploratory work was initiated following discovery of significant jet fuel contamination (flowing product) during trenching for a 12KV electric line in December 1988. The geophysical survey indicated a possible underground storage tank (UST) in the area, but no UST was found during subsequent excavation work. Historical aerial photography and site plans indicated an above ground storage tank was located in the area.

Results of the exploratory excavations indicated that the remnant pipeline and valves above ground at the site are part of an old water distribution system for fire protection. However, old underground fuel pipelines and jet fuel contaminated soil were also found.

### 2.5.3 Site Geology

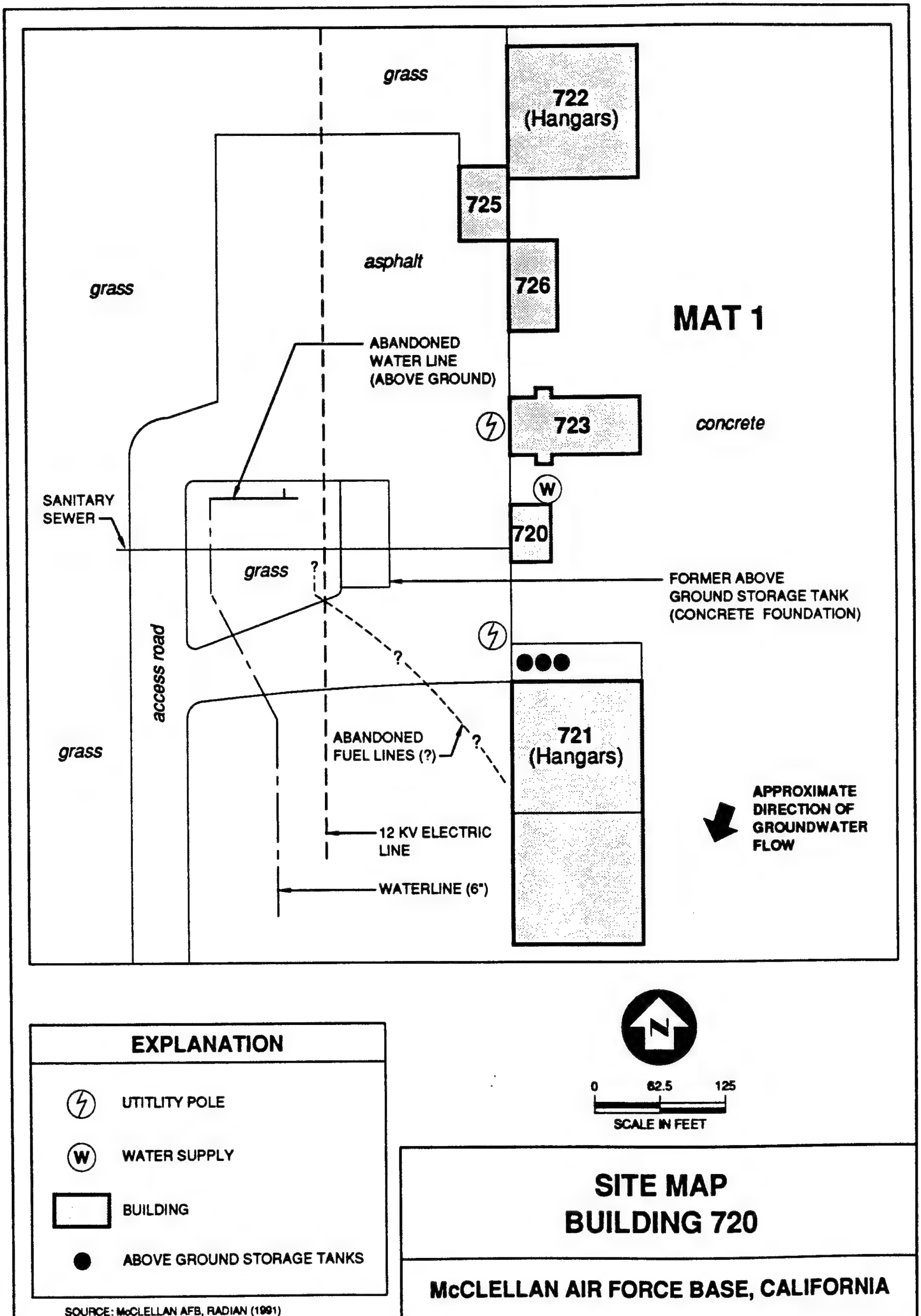
No deep exploratory borings have been performed and no monitoring wells have been installed in the immediate vicinity of Building 720. Therefore, evaluation of the geology and hydrogeology is based on previous geologic and hydrogeologic studies of OU C and the near-surface exploratory excavations.

Figure 2.16 is the well log for monitoring well MW-45S, the nearest downgradient monitoring well to Building 720, located approximately 500 feet southwest of the contaminated area (Figure 2.2). The soil profile encountered in MW-45S from ground surface to 100 feet bgs is predominantly interbedded clays and silts with occasional thin sand and gravels zones. A near-surface layer of hardpan was also encountered. Other logs for monitoring wells and soil borings located in OU C indicate similar profiles.

Near-surface exploratory excavations at the contaminated area encountered sandy clay and debris from ground surface to about 1 foot bgs. A river rock (1 -inch diameter) interval about 8 inches in thickness underlies the sandy clay. Underlying the river rock is another sandy clay layer about 4 feet in thickness followed by a hardpan layer of unknown thickness encountered at about 6 feet bgs. An old concrete foundation may also exist below ground surface at the site, but this has not been confirmed.

Groundwater was encountered in MW-45S at 86 feet bgs at the time of drilling in August 1982 (Engineering-Science 1983). Groundwater levels measured in March 1987 for other A-aquifer zone monitoring wells in OU C are also at about 80 to 90 feet bgs.

FIGURE 2.15




**SITE MAP**
**BUILDING 720**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 2 C245-13.DWG 01/13/94

ENGINEERING-SCIENCE, INC.

Figure 2.16

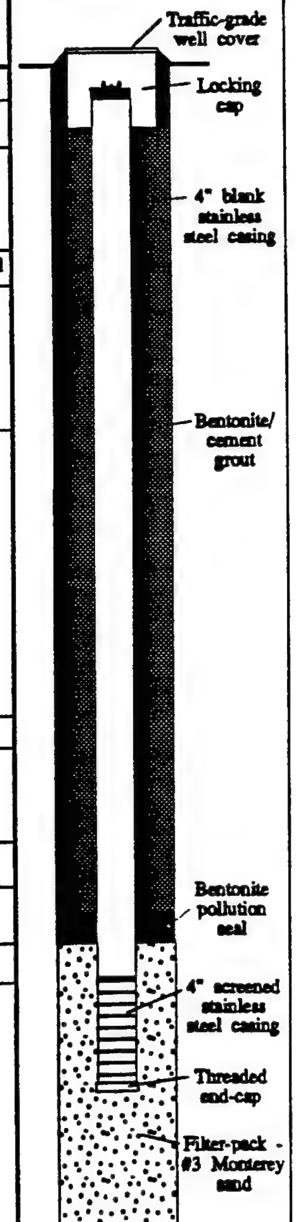
**ES ENGINEERING-SCIENCE**

**BOREHOLE NUMBER: 45S**

| | |
|---|---|
| PROJECT NUMBER: File 9793 | PROJECT NAME: McClellan AFB |
| CLIENT: McClellan AFB | DRILLER: Water Development Corp. |
| LOCATION: | DRILLING METHOD: Mud Rotary |
| | |
| GEOLOGIST: F.H. | HOLE DIAMETER: 8.5 inches |
| COMPLETION DATE: 25 August 1982 | TOTAL DEPTH: 102 feet |

| DEPTH feet | SAMPLE LOCATION | SAMPLE NUMBER | BLOW COUNT | PID (ppm) | GRAPHIC LOG | SOIL CLASS | GEOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | CL | CLAY, brown, dry, very stiff, "hardpan" |
| | | | | | | SP | Medium-grained SAND, brown, slightly dense |
| 10 | | | | | | CL | Interbedded SILT and CLAY, red-brown silt and green-brown clay, dense |
| | | | | | | SP | Medium-grained SAND, brown, dense, with occasional gravel |
| 20 | | | | | | CL | Silty CLAY, brown to green brown, very stiff, with interbedded silt (ML) after 28 feet below ground surface. |
| 30, 40, 50 | | | | | | ML | Clayey SILT, gray-brown, slightly stiff, easier drilling |
| | | | | | | GW | ("no sample - crunchy drilling") |
| 60 | | | | | | CL | Silty CLAY, brown to red-brown and green-brown, very stiff, slow drilling |
| 70 | | | | | | SP | Medium-grained SAND, brown, dense, peppered |
| | | | | | | CL | Silty CLAY, green-brown, stiff to very stiff |
| | | | | | | SW | ("No sample - drilled like sand") |
| 80, 90, 100 | ▽ | | | | | ML | SILT, brown, with sandy interbeds |
| | | | | | | | Bottom of borehole |

MONITORING WELL CONSTRUCTION




▼ - Equilibrated waterlevel.

▽ - First encountered groundwater.

▮ - Brass tube sample submitted for laboratory analysis.

mc45s

Source: Based on original boring log (Engineering-Science, Inc. 1983)

Groundwater flow in the A-aquifer beneath the site is generally to the south-southwest based on groundwater levels measured in 1987, 1990, and 1991 (Radian 1992). The hydraulic gradient is very gentle, approximately 0.002 ft/ft. A limited number of aquifer pumping tests in OU C indicate an average groundwater flow velocity of about 200 ft/yr, although this value appears to vary considerably because of the varying local thickness of the aquifer.

Soil moisture was measured at numerous exploratory borings performed as part of a surface impoundment study (EG&G INEL 1988) approximately 600 to 1000 feet west of Building 720. The average moisture content was about 23% at depths ranging from 29 to 70 feet bgs.

### 2.5.4 Site Contaminants

The primary contaminants documented in soils at the Building 720 site are fuel residuals and aromatic hydrocarbons. Locations of soil samples collected during trenching of the 12KV electric line are shown in Figure 2.17. Table 2.5 presents the analytical data for the six soil samples collected. Soil samples were collected at two depths at each sample location. During the exploratory excavations performed in the area, visible evidence of contaminated soils was also noted in the vicinity of S3 and an area west of S2. No information on possible contamination below near surface soils exists.

Soil samples were analyzed for total petroleum hydrocarbons (TPH) and purgeable aromatic hydrocarbons including benzene, toluene, ethylbenzene, and total xylenes (BTEX). The maximum levels found were 1,200 mg/kg TPH-g, 470 mg/kg TPH-mo, 0.27 mg/kg benzene, 2.88 mg/kg toluene, 9.81 mg/kg ethylbenzene, and 4.24 mg/kg total xylenes. These maximums were all at location S3 from 1 foot bgs. Samples from location S1 did not have detectable concentrations of these analytes and results from S2 showed relatively low concentrations. All soil samples were also analyzed for halogenated volatile organic compounds (VOCs) using EPA Method 8010 and all were below detection limits. Samples taken from S1 and S2 were also analyzed for semivolatile organic compounds (SVOCs) using expanded EPA Method 8270. SVOCs were detected above detection limits only at S2 at 3.5 feet bgs at the following concentrations: 0.65 mg/kg naphthalene, 0.96 mg/kg 2-methylnaphthalene, 0.39 mg/kg butyl benzyl phthalate, and 0.38 mg/kg isophorone.

## 2.6 Davis Site

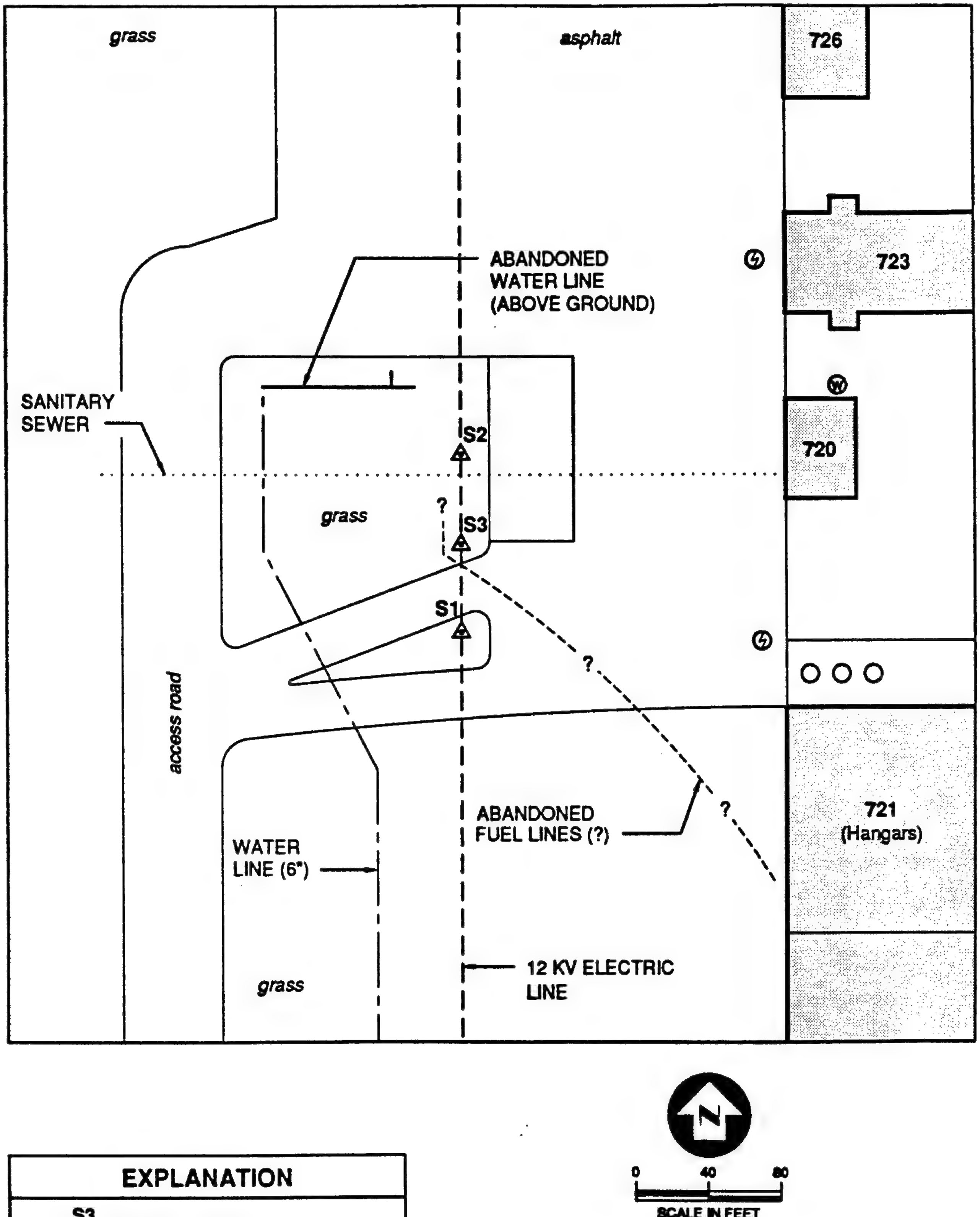
### 2.6.1 Site Location and Description

The bioventing pilot test at the Davis Site will take place at the former location of three underground fuel storage tanks (UFSTs). The UFSTs were located in the southeast portion of the Main Compound Area, south of Building 4710 (Figure 2.18). This area is grass covered with nearby asphalt roadways.

### 2.6.2 Site History

The three 25,000 gallon UFSTs were used to store diesel fuel for the generator housed in Building 4710. In February 1985, approximately 52 cubic yards of soil above the

FIGURE 2.17




| EXPLANATION |
| --- |
| S3 SAMPLE LOCATION |
| UTILITY POLE |
| WATER SUPPLY |
| BUILDING |
| ABOVE GROUND STORAGE TANKS |

SOURCE: McCLELLAN AFB, MODIFIED FROM RADIAN (1991)

## SAMPLING LOCATIONS BUILDING 720

McCLELLAN AIR FORCE BASE, CALIFORNIA

C254-04.R0 05/05/93 12:49

ENGINEERING-SCIENCE, INC.

# Table 2.5
# Soil Contaminant Concentrations at Building 720
# McClellan AFB, California

| | | Total Petroleum Hydrocarbons | | | | Purgeable Aromatics | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method: | CA LUFT Mod. 8015 | | | | 8020 | | | |
| | Analyte: | TPH-g | TPH-jf | TPH-d | TPH-mo | Benzene | Toluene | Ethylbenzene | Total Xylenes |
| **Location** | **Depth (ft bgs)** | **concentrations in mg/kg** | | | | | | | |
| **S1** | 2.5 | <10 | <10 | <10 | <10 | <1.0 | <1.0 | <1.0 | <1.0 |
| | 5.0 | <10 | <10 | <10 | <10 | <1.0 | <1.0 | <1.0 | <1.0 |
| **S2** | 3.5 | <10 | 214 | <10 | <10 | <1.0 | <1.0 | <1.0 | <1.0 |
| | 6.0 | <10 | 13 | <10 | <10 | <1.0 | <1.0 | <1.0 | <1.0 |
| **S3** | 1.0 | 1,200* | n.r. | <10 | 470 | 0.27 | 2.88 | 9.81 | 4.24 |
| | 3.0 | 790* | n.r. | <10 | 390 | 0.18 | 2.52 | 7.38 | 3.54 |

*LEGEND*

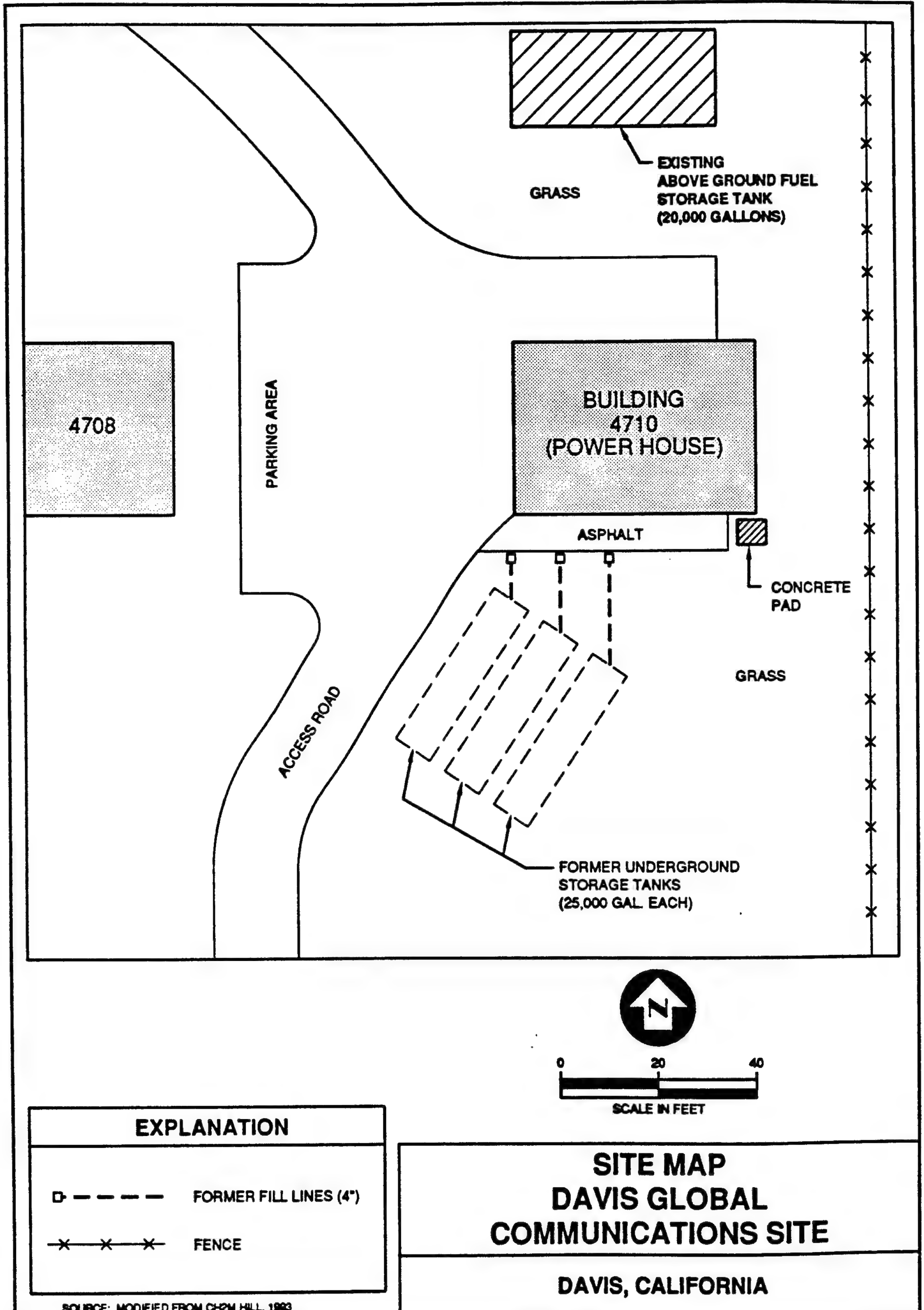
bgs : below ground surface
* : carbon range reported as C9-C14
TPH-g : total petroleum hydrocarbons as gasoline
TPH-jf : total petroleum hydrocarbons as jet fuel
TPH-d : total petroleum hydrocarbons as diesel
TPH-mo : total petroleum hydrocarbons as motor oil
n.r. : not reported
<10 : below given detection limit

b720

SOURCE: McClellan AFB, 1989

03/29/93

FIGURE 2.18




## SITE MAP
## DAVIS GLOBAL COMMUNICATIONS SITE

DAVIS, CALIFORNIA

REV. 2 C250-04.DWG 05/13/93

ENGINEERING-SCIENCE, INC.

UFSTs was removed and found to be saturated with petroleum product. The pipelines associated with the UFSTs were found to be leaking and the exposed tanks showed deformation. In May 1985, a replacement 20,000-gallon above ground tank was installed north of Building 4710 and the UFSTs were emptied. In December 1985, investigations revealed that soils adjacent to the UFSTs were contaminated with petroleum hydrocarbons. In May 1988, the UFSTs were removed and the excavation was backfilled with clean soil. Subsequent investigations have been performed to determine the extent of soil and groundwater contamination at the site (IT Corporation 1992, CH2M Hill 1993).

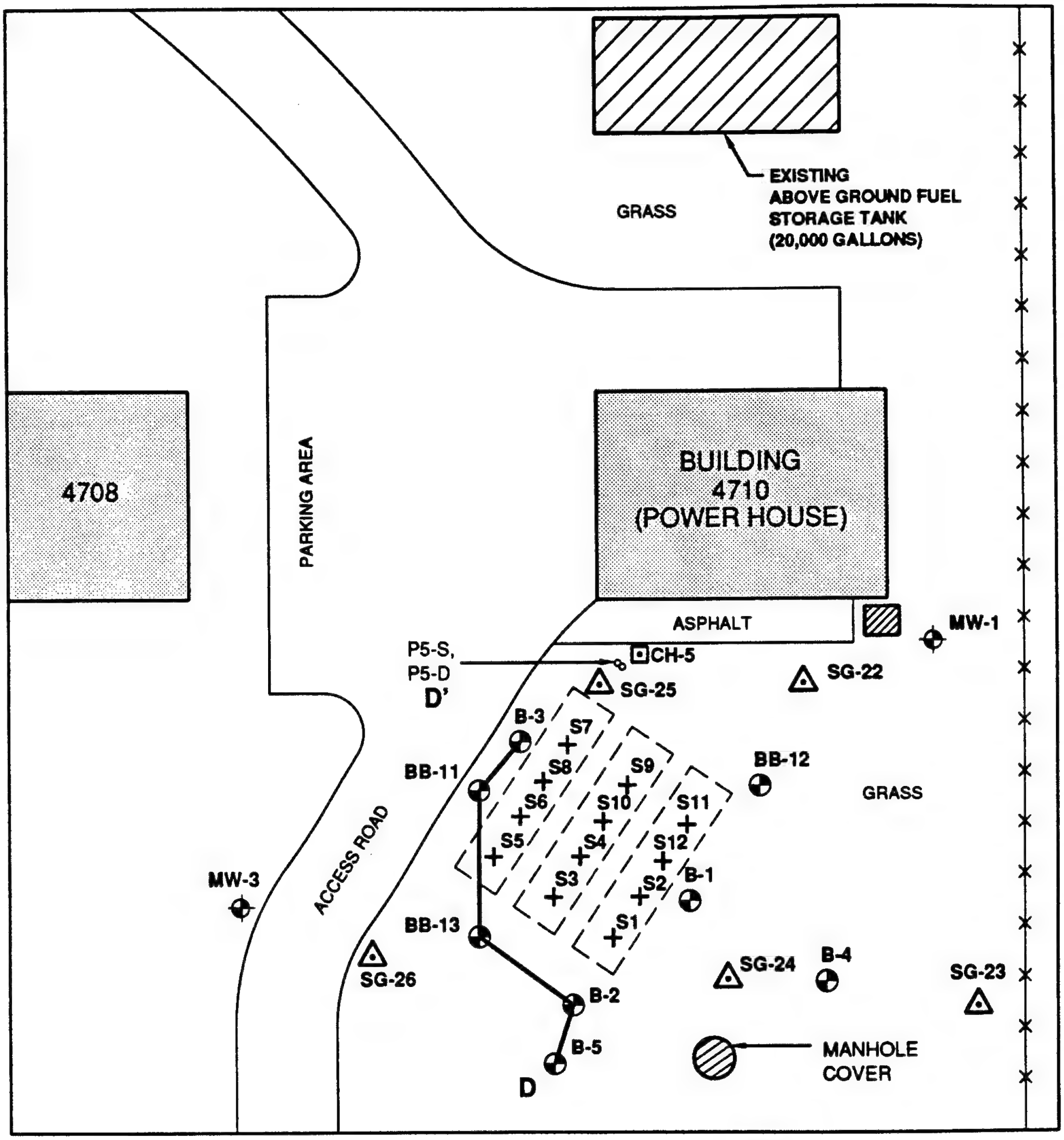
In May 1987, concentrations of trichloroethene (TCE) and tetrachloroethene (PCE) exceeding state actions levels were detected in groundwater from the on-site production well. Further investigations delineated TCE and PCE plumes and also indicated that additional VOCs are present in the groundwater.

### 2.6.3 Site Geology

In the vicinity of the UFST excavation, eight soil borings have been performed and two groundwater monitoring wells have been installed as part of previous IRP investigations (Figure 2.19). Evaluation of the geology and hydrogeology of the site is based on results from these soil borings and from ongoing groundwater investigations.

Figure 2.20 shows geologic cross-section D-D', constructed from five of the soil borings and follows a generally south to north line along the excavated area. The site is underlain by sands, silts, and clays. The uppermost unit is a silt interval, approximately 2 to 10 feet in thickness. In BB-11 and BB-13, the two central borings, this silt interval is underlain by a sand interval approximately 4 feet in thickness. Beneath the silt and the small sand body is a laterally continuous clay interval extending to a depth of approximately 25 feet bgs. This clay interval is underlain by a laterally continuous sand interval extending to a depth of approximately 35 feet bgs. The sand layer becomes siltier in the two northernmost borings (BB-11 and B-3) and its basal portion is a gravel log deposit found in most of the borings. Beneath the sand layer are discontinuous clay and silt intervals. Sand was encountered at approximately 65 feet bgs in the two deepest borings (BB-11 and BB-13).

The site is underlain by six water-bearing zones or aquifers. The uppermost zone is referred to as the B-aquifer and lies between 75 and 85 feet below ground surface. In the B-aquifer, groundwater flow directions and velocities appear to change significantly throughout the year probably due to agricultural groundwater withdrawals. Winter conditions are represented by westward groundwater flow, shallow groundwater (30 to 40 feet bgs), and a relatively low horizontal gradient (0.001 ft/ft). Summer conditions are represented by groundwater flow to the south, significantly deeper groundwater (60 to 70 feet bgs), and a steeper hydraulic gradient (0.01 ft/ft). Aquifer testing of B-aquifer wells in 1991 indicate summer and winter groundwater flow velocities of 5.13 ft/day (1,770 ft/year) and 0.65 ft/day (240 ft/yr), respectively (IT Corporation 1992). These widely varying velocities are likely due to the seasonal variation in hydraulic gradients caused by local pumping wells.




**EXPLANATION**

| | |
|---|---|
| MW-1 | GROUNDWATER MONITORING WELL |
| B-4 | SOIL BORING |
| SG-26 | SOIL GAS SAMPLE |
| CH-5 | VAPOR EXTRACTION WELL |
| P5-S | VAPOR PIEZOMETER |
| S3 | SOIL SAMPLE |
| | FENCE |

SOURCE: MODIFIED FROM CH2M HILL, 1993

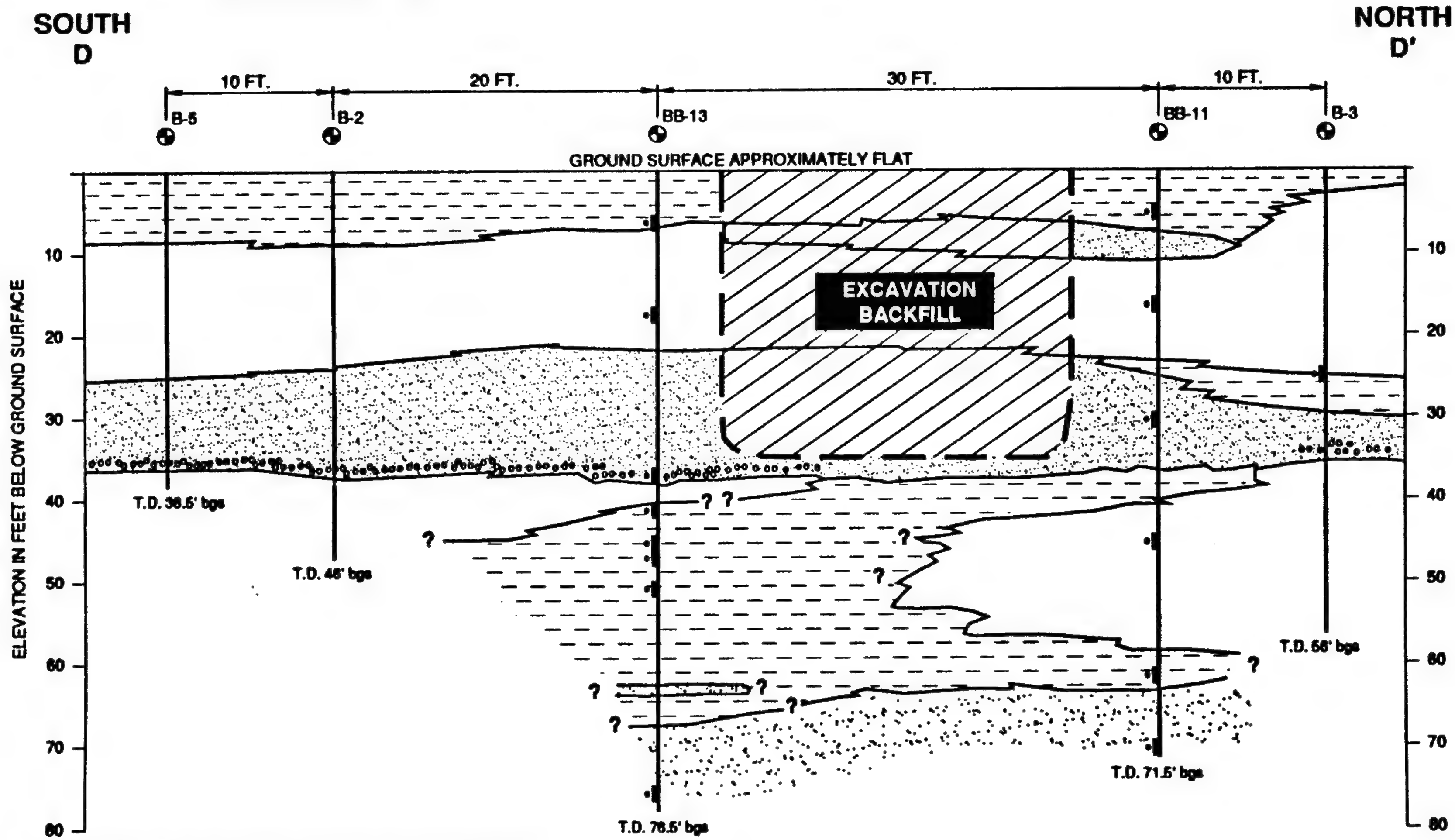
# SITE MAP
# DAVIS GLOBAL COMMUNICATIONS SITE

DAVIS, CALIFORNIA

REV. 2 C257-23.DWG 01/13/94

ENGINEERING-SCIENCE, INC.

FIGURE 2.20




NOTE: CROSS-SECTION BASED ON SOIL BORING DATA FROM IT CORPORATION (1992). ALL SOIL SAMPLE INTERVALS NOT AVAILABLE FOR B-2, B-3, AND B-5.

## EXPLANATION

- B-5 SOIL BORING
- SOIL SAMPLE INTERVAL (DOT SHOWS SAMPLE ANALYZED)
- GEOLOGIC CONTACT

## LITHOLOGIC DESCRIPTION

- SANDS WITH GRAVEL
- SANDS
- SILTS
- CLAYS

SCALE IN FEET ((HORIZONTAL EXAGGERATION IS 2X)

0 5 10

# GEOLOGIC CROSS-SECTION D-D' DAVIS GLOBAL COMMUNICATIONS SITE

## DAVIS, CALIFORNIA

REV. 3 C254-03.DWG 05/20/93

ENGINEERING-SCIENCE, INC.

### 2.6.4 Site Contaminants

The primary contaminants documented in soils at the site are fuel residuals, aromatic hydrocarbons, trichloroethene (TCE), and tetrachloroethene (PCE). Semivolatile organic compounds (SVOCS) were also detected, but were polynuclear aromatic hydrocarbons (PAHs), common minor components of diesel fuel and heavier oils. Table 2.6a summarizes the analytical results for soil samples collected in the vicinity of the UFSTs. Locations for most of these samples are shown on the cross-section in Figure 2.20. Table 2.6b summarizes the analytical results for soil samples taken from the bottom of the excavation after UFST removal operations. These sample locations are shown in Figure 2.19.

The maximum detected concentration of TPH was 17,236 mg/kg at soil boring B-3 at 25 feet bgs. Generally, TPH contamination decreases with depth although concentrations of approximately 2,000 mg/kg were found as deep as 60 feet bgs (BB-11 and BB-12). Elevated levels also generally decrease with horizontal distance away from the UFST excavation; however, TPH was detected at 310 mg/kg at 51 feet bgs approximately 75 feet south of the excavation during drilling of a monitoring well.

Soil samples collected from the bottom of the excavation were highly contaminated with TPH-d and PAHs, consistent with the widespread visual evidence of contamination observed during UFST removal operations. The highest levels were found in the center of the excavation and at the southwestern corner of the excavation.

An extensive soil gas survey of the Davis Site included samples taken in the vicinity of the UFST excavation. Detected contaminants included benzene, toluene, ethylbenzene and total xylenes (BTEX), TCE, and PCE. Analytical results for soil-gas samples near the UFST excavation are shown in Table 2.6c. The highest levels of BTEX contamination were found in soil-gas samples collected near the former tank fill lines. Other contaminants detected in soil-gas samples near the UFST excavation (not shown in Table 2.6c) were 0.10 ppmv Freon 12, 0.51 ppmv vinyl chloride, 0.0087 ppmv 1,1-dichloroethane, and 0.012 ppmv cis-1,2-dichloroethene.

During the soil-gas survey, atmospheric gases were also measured at CH-5 at a depth of 28 to 38 feet. Measured levels were 0% oxygen (non-detect), 10% carbon dioxide, 1.5% methane, and 0.091% total non-methane hydrocarbons (CH2M Hill 1993). The complete depletion of oxygen and the high level of carbon dioxide measured in the soil-gas is indicative of biological activity. However, the biodegradation is probably severely constrained by a lack of adequate oxygen.

PCE and TCE have been detected in soil-gas northeast of Building 4710 and southeast of Building 4710. The origin of the TCE and PCE contamination is unknown although it is likely related to past disposal practices. PCE and TCE have been detected in groundwater throughout the site and in multiple aquifers.

Analytical results for groundwater samples from the B-aquifer have consistently detected chlorinated VOCs, principally TCE, PCE, and vinyl chloride, at monitoring wells throughout the Davis Global Communications Site. In May 1991, maximum

# Table 2.6a
# Soil Boring Sample Contaminant Concentrations
# Davis Global Communications Site
# Davis, California

| | | Petroleum HC |
|---|---|---|
| | Method: | not reported |
| | Analyte: | TPH |
| Location | Depth (ft bgs) | concentrations in mg/kg |
| B-1* | 35 | 4,767 |
| B-3* | 25 | 17,236 |
| BB-11 | 5 | 1,200 |
| | 16 | 190 |
| | 31 | 660 |
| | 46 | 210 |
| | 62 | 2,100 |
| | 71 | ND |
| BB-12* | 61 | 1,800 |
| BB-13 | 6 | ND |
| | 16 | ND |
| | 36 | 1,300 |
| | 41 | 110 |
| | 46 | 220 |
| | 47 | 230 |
| | 51 | 150 |
| | 76 | ND |
| MW-1 | 26 | 50 |
| | 31 | <10 |
| | 46 | 690 |
| | 66 | <10 |
| MW-3* | 61 | 100 |

*LEGEND*

bgs : below ground surface

TPH : total petroleum hydrocarbons

* : Only the maximum concentration was reported for this location.

ND : not detected; detection limit not reported

dav_sb

SOURCE: IT Corporation, 1992

04/28/93

## Table 2.6b
## Tank Hold Soil Sample Contaminant Concentrations at Davis Global Communications Site Davis, California

| | | Petroleum HC | | | Purgeable Aromatics | | | | Semivolatile Organic Compounds | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Method: | 8015 | | | 8020 | | | | 8270 | | | | | | |
| | Analyte: | TPH-g | TPH-d | TPH-mo | Benzene | Toluene | Ethyl Benzene | Total Xylenes | 2-Methyl Naph-thalene | Fluorene | Naph-thalene | Phenan-threne | Pyrene | Bis (2-ethylhexyl) Phthalate | Dibenzo-furan |
| Location | Depth (ft bgs)* | concentrations in mg/kg | | | | | | | | | | | | | |
| S1 | 30 | <10 | 522 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 2.2 | 1.10 | <0.150 | 2.10 | <0.150 | 1.10 | <0.500 |
| S2 | 30 | <10 | 136 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 1.0 | 0.60 | <0.150 | 1.10 | <0.150 | 1.40 | <0.500 |
| S3 | 30 | <10 | 270 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 1.1 | 0.45 | <0.150 | 0.83 | <0.150 | 1.30 | <0.500 |
| S4 | 30 | <10 | 9,120 | <10 | 0.086 | 0.060 | 0.55 | 0.78 | 46.5 | 6.90 | 21.1 | 14.40 | <0.150 | 0.93 | 2.20 |
| S5 | 30 | <10 | 6,000 | <10 | 0.060 | 0.031 | 0.20 | 0.38 | 38.1 | 5.50 | 18.7 | 14.00 | 0.70 | 1.20 | 2.20 |
| S6 | 30 | <10 | 4,700 | 85 | 0.074 | 0.051 | 0.20 | 0.55 | 40.6 | 4.80 | 19.9 | 14.50 | <0.150 | 1.20 | 0.90 |
| S7 | 30 | <10 | 1,980 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 18.0 | 2.50 | 7.4 | 6.00 | 0.25 | 1.20 | 0.85 |
| S8 | 30 | <10 | 2,100 | <10 | <0.005 | <0.005 | 0.23 | 0.33 | 16.2 | 2.00 | 6.2 | 4.60 | 0.22 | 1.50 | <0.500 |
| S9 | 30 | <10 | 1,590 | 29 | <0.005 | <0.005 | <0.005 | <0.005 | 14.8 | 2.00 | 5.7 | 4.10 | 0.19 | 1.50 | <0.500 |
| S10 | 30 | <10 | 3,790 | <10 | <0.005 | 0.100 | 0.10 | 0.26 | 24.1 | 2.70 | 8.5 | 8.60 | 0.38 | 1.10 | 0.54 |
| S11 | 30 | <10 | 435 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 6.3 | 0.74 | 2.1 | 0.92 | <0.150 | 2.40 | <0.500 |
| S12 | 30 | <10 | 1,890 | <10 | <0.005 | <0.005 | <0.005 | <0.005 | 11.7 | 1.60 | 3.8 | 2.50 | <0.150 | 1.40 | 0.53 |

*LEGEND*

bgs : below ground surface
* : estimate
TPH-g : total petroleum hydrocarbons as gasoline
TPH-d : total petroleum hydrocarbons as diesel
TPH-mo : total petroleum hydrocarbons as motor oil
<10 : below given detection limit

SOURCE: IT Corporation, 1992

dav_st
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# Table 2.6c
# Soil Gas Concentrations at
# Davis Global Communications Site
# Davis, California

| | | Volatile Organic Compounds | | | | | |
|---|---|---|---|---|---|---|---|
| | **Method:** | EPA TO-14/EPA 8021 (modified)* | | | | | |
| | **Analyte:** | Benzene | Toluene | Ethylbenzene | Total Xylenes | TCE | PCE |
| **Location** | **Depth (ft bgs)** | **concentrations in ppmv** | | | | | |
| CH-5 | 28-38 | 0.36 | ND | 0.019 | n.r. | 0.017 | 0.091 |
| P-5S | 17.5-20 | ND | ND | ND | n.r. | 6.2 | ND |
| SG22-10A | 10 | ND | ND | ND | ND | 0.017 | 5.800 |
| SG22-10B | 10 | ND | ND | ND | ND | ND | 7.000 |
| SG23-10A | 10 | ND | 0.021 | ND | 0.018 | ND | 0.010 |
| SG24-10A | 10 | ND | ND | ND | ND | ND | ND |
| SG24-10B | 10 | ND | ND | ND | ND | ND | ND |
| SG25-10A | 10 | ND | 0.371 | 0.270 | 1.56 | ND | 0.001 |
| SG26-10A | 10 | ND | ND | ND | ND | ND | ND |

*LEGEND*

bgs : below ground surface

* : CH-5 and P-5S were analyzed by method TO-14.
All other samples were analyzed by modified method 8021.

n.r. : not reported

ND : not detected; detection limit not reported

dav_sg

04/28/93

SOURCE: CH2M Hill, 1993 (draft).

detected levels for monitoring wells closest to the excavation were: 200 µg/L TCE, 100 µg/L PCE, and 290 µg/L vinyl chloride. Dissolved petroleum hydrocarbons have also been found in groundwater at MW-2, approximately 100 feet south of the former tank excavation, and at MW-3 (Figure 2.19).

## 3.0 SITE-SPECIFIC ACTIVITIES

The purpose of this section is to describe the work that will be performed by Engineering-Science, Inc. (ES) at each of the six sites. Activities that will be performed at each site include siting and construction of a central VW and VMPs, an initial pilot test (including an air permeability test and an *in situ* respiration test), and an extended (one-year) pilot test. Soil and soil-gas sampling procedures and the blower configuration that will be used to introduce air (oxygen) into contaminated soils by injection are also discussed in this section.

No dewatering or groundwater treatment will take place during the pilot testing. Pilot test activities will be confined to unsaturated soils remediation. Existing monitoring wells will not be used as primary air injection wells; however, monitoring wells which are known to have a portion of their screened interval above the water table may be used as VMPs or used to measure the composition of background soil gas. The only site which has monitoring wells which meets this criteria is the Davis site, discussed in Section 3.1.6.

Subsurface soils at four of the six sites (Tank Farm #2, Tank Farm #4, SA 6, and PRL T-46) are expected to be composed of mostly interbedded sands, silts, and silty sands which should be very suitable for the bioventing technology. At the remaining two sites (Building 720 and the Davis Site), subsurface soils will likely contain significant intervals of clay. However, since recent studies have shown that bioventing can be effective in low permeability soils (Downey at al. 1992), these sites could also be suitable for the bioventing technology. Soils at all sites are expected to contain sufficient moisture and nutrients to sustain respiration and biodegradation for the duration of the tests.

### 3.1 Locations of Vent Wells and Vapor Monitoring Points

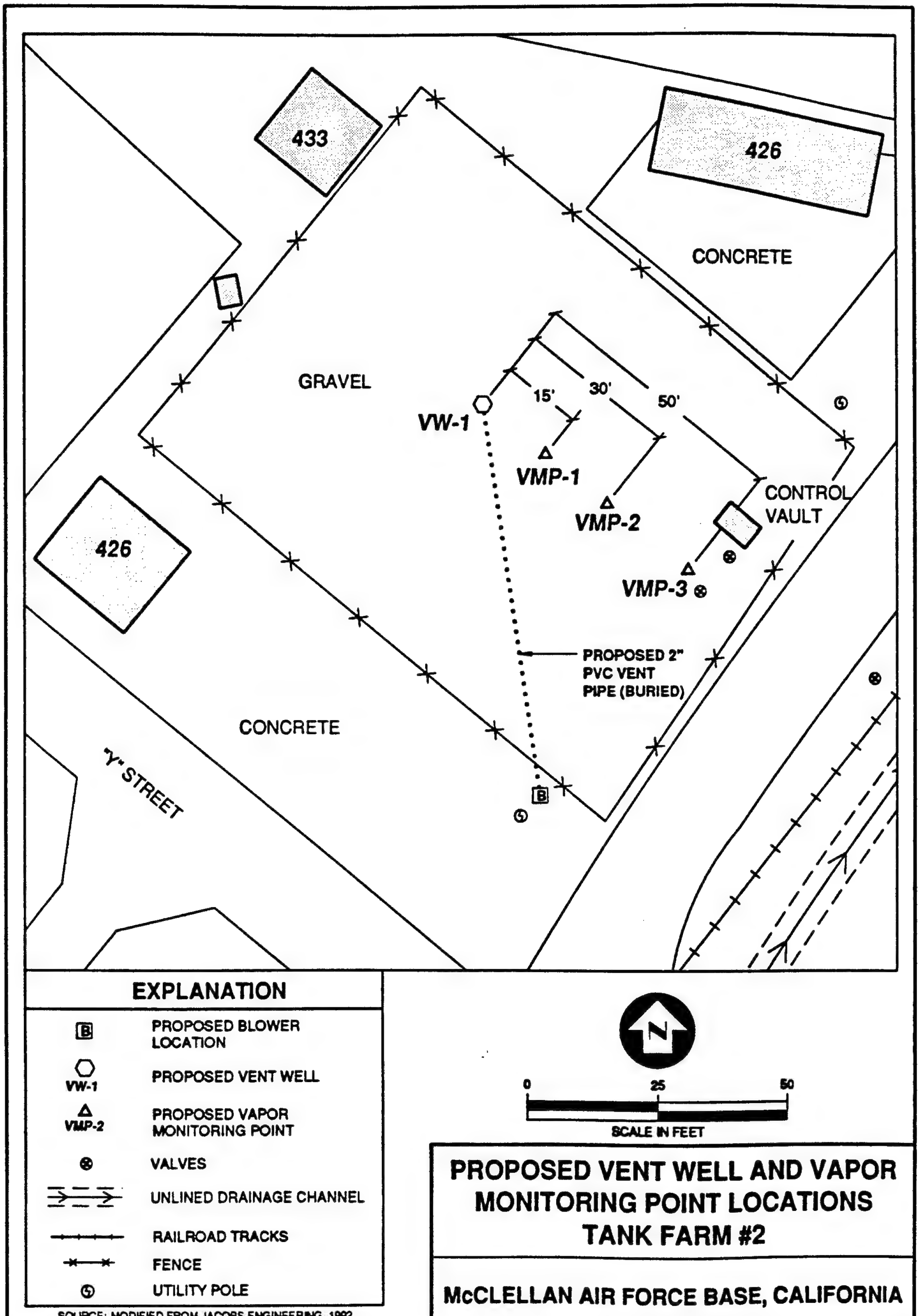
A general description of criteria used for siting a central VW and VMPs is included in the protocol document. The proposed VW and VMP locations and the siting criteria used for each site are described below. The proposed locations for the two background VMPs are described in Section 3.1.7.

The final location of VWs and VMPs may vary slightly from the proposed location if evidence of significant fuel contamination is not observed in borings. VWs will be located in areas of high fuel contamination which also is expected to be oxygen depleted (less than 2%). Increased biological activity should be stimulated by oxygen-rich soil gas ventilation during both the initial and extended pilot tests.

#### 3.1.1 Tank Farm #2

Figure 3.1 shows the proposed location of the blower, the central VW, and the VMPs for Tank Farm #2. The VW location was chosen based upon the high degree of contamination at soil boring B-18 and soil sample S3 (see Figure 2.5 and Table 2.1). In addition, contamination is expected along the line of former UFSTs and known fuel spills have occurred from the valves at southeastern edge of the site. Although the backfill is

FIGURE 3.1




PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS TANK FARM #2

McCLELLAN AIR FORCE BASE, CALIFORNIA

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also contaminated, the VW will only be partially screened within the backfill in order to avoid excessive short circuiting of air to the surface.

The radius of venting influence around the central VW is expected to be about 40 to 60 feet based upon the predominance of sands and silts in subsurface soils at the site and upon the expected depth of contamination at greater than 20 feet. The three VMPs are to be located at distances from the central VW which should provide adequate coverage over this expected radius of influence.

### 3.1.2 Tank Farm #4

Figure 3.2 shows the proposed location of the blower, the central VW, and the VMPs for Tank Farm #4. The VW location was chosen based upon the high degree of contamination observed at the fuel distribution piping during UFST removal and the analytical results for soil sample location S1 (see Figure 2.7 and Table 2.2). Since the backfill is also contaminated, the VW will be partially screened within the backfill but not so as to cause excessive short circuiting of air to the surface. In order to reduce costs and mitigate impacts to base operations, a subsurface 2-inch diameter PVC vent pipe has already been installed at this site in coordination with a base paving operation.

The radius of venting influence around the central VW is expected to be about 40 to 60 feet based upon the predominance of sands and silts in subsurface soils at the site and upon the expected depth of contamination at greater than 20 feet. The three VMPs are to be located at distances from the central VW which should provide adequate coverage over this expected radius of influence.

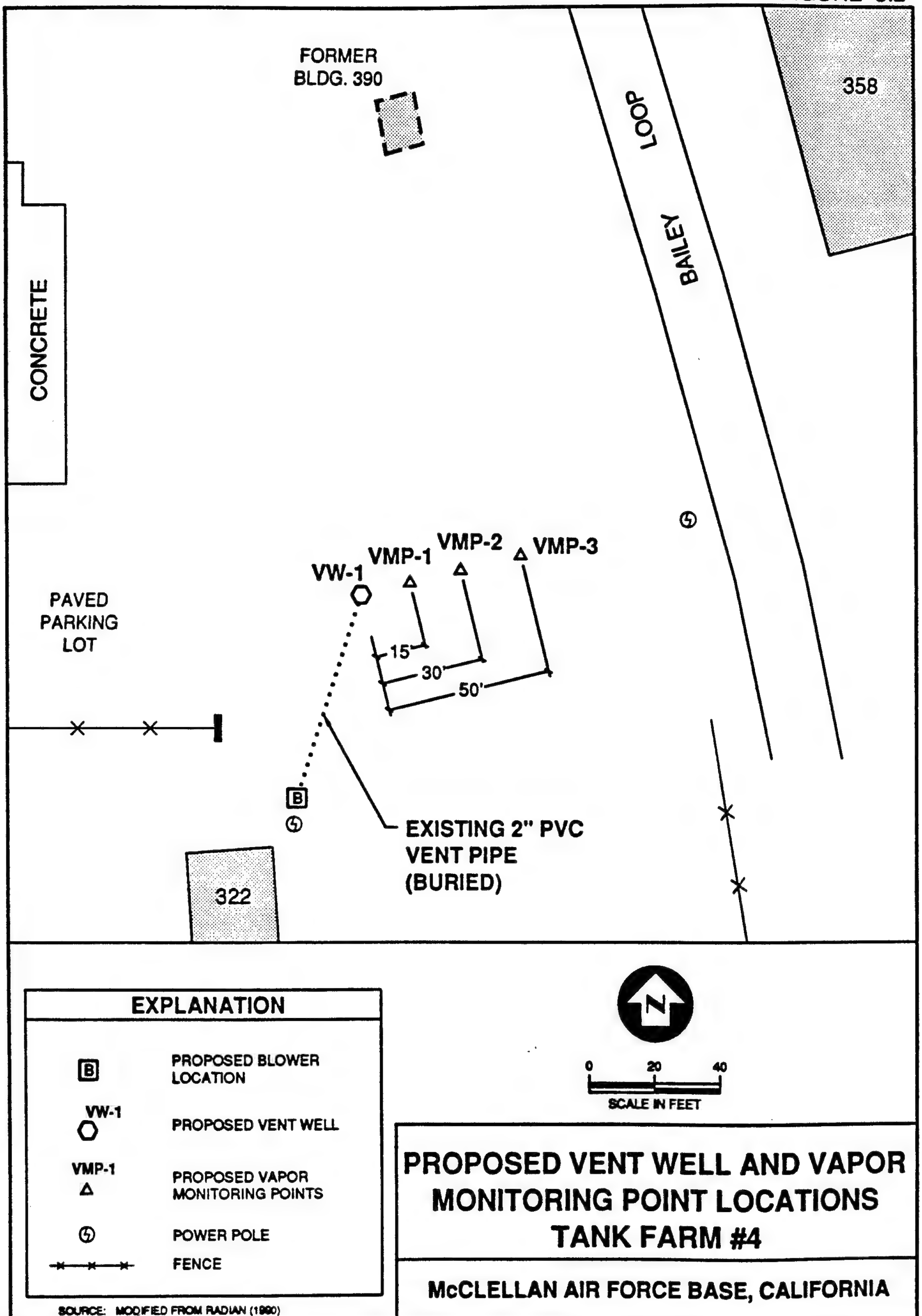
### 3.1.3 SA 6

Figure 3.3 shows the proposed location of the blower, the existing central VW, and the existing VMPs which have already been installed at SA 6 by Radian Corporation in February 1993. Vent well VW-18 will be used for venting during the initial pilot test. This choice was based upon the high degree of contamination in soil gas observed during drilling and is consistent with the high contamination levels found during previous investigations at soil boring B6 (see Figure 2.10 and Table 2.3). VW-19 was constructed as a VW but will be used during the initial pilot test as a vapor monitoring point. During the extended (one-year) pilot test, VW-19 will be used as an additional vent well if initial pilot test results indicate a single blower could vent two wells.

Because significant levels of contamination were not observed in soil gas at VW-7, the primary VMP for the site, an additional VMP may be installed north of VW-18 (see Figure 3.3) if oxygen depletion is not observed or respiration test results are poor.

The radius of venting influence around the central VW is expected to be about 40 to 60 feet based upon the predominance of sands and silts in subsurface soils at the site and upon the existing screened interval of the central VW (VW-18) from 25 to 100 feet bgs. Because the three VMPs (VW-7, VPN-16, and VW-19) were all located at approximately the same distance from the central VW, full coverage over the expected radius of influence may be limited. The additional VMP shown on Figure 3.3 may be necessary if air permeability test results do not adequately characterize the radius of influence.

FIGURE 3.2




**PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS TANK FARM #4**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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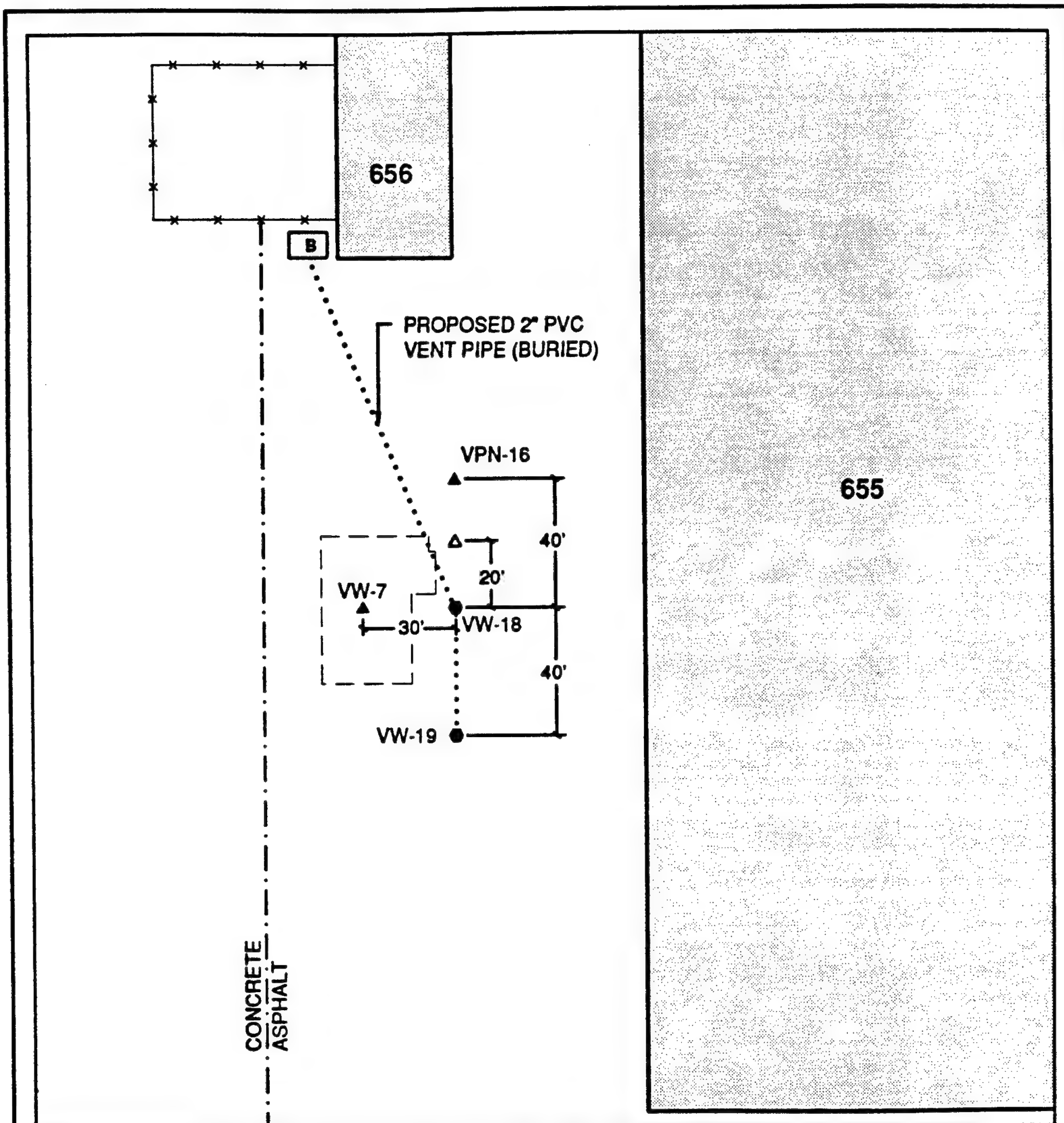
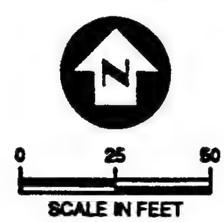
FIGURE 3.3




NOTE: DESPITE THE DESIGNATION, VW-7 WAS CONSTRUCTED AS A VAPOR MONITORING POINT

**EXPLANATION**

| | |
|---|---|
| 656 | EXISTING BUILDING |
| —·— | CONCRETE/ASPHALT BORDER |
| B | PROPOSED BLOWER LOCATION |
| ▲ VPN-16 | EXISTING VAPOR MONITORING POINT |
| ● VW-18 | EXISTING VENT WELL |
| △ | PROPOSED VAPOR MONITORING POINT |
| —x—x—x— | FENCE |
| ⌐ ¬ | EXCAVATED AREA (FORMER UFSTs) |




**EXISTING/PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS SA 6**

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### 3.1.4 PRL T-46

Figure 3.4 shows the proposed location of the blower, the central VW, and the VMPs for PRL T-46. The VW location was chosen based upon the analytical results for soil borings B21 and B22, where the highest levels of contamination were found (see Figure 2.13 and Tables 2.4a and 2.4b). Contamination also has likely resulted from leaks along the drain lines or where the drain lines met the oil/water separator tank; therefore, the VMPs are to be positioned along the drain lines.

The radius of venting influence around the central VW is expected to be about 20 to 40 feet based upon the predominance of sands and silts in subsurface soils at the site and upon the existence of significant contamination at a very shallow depth. The three VMPs are to be located at distances from the central VW which should provide adequate coverage over this expected radius of influence.

### 3.1.5 Building 720

Figure 3.5 shows the proposed location of the blower, the central VW, and the VMPs for Building 720. The VW location was chosen based upon the analytical results for soil sample S3 (see Figure 2.17 and Table 2.5) and visual evidence of contamination in the area during shallow soil excavations. Contamination also has likely resulted from leaks along the abandoned fuel line suspected to exist in this area.

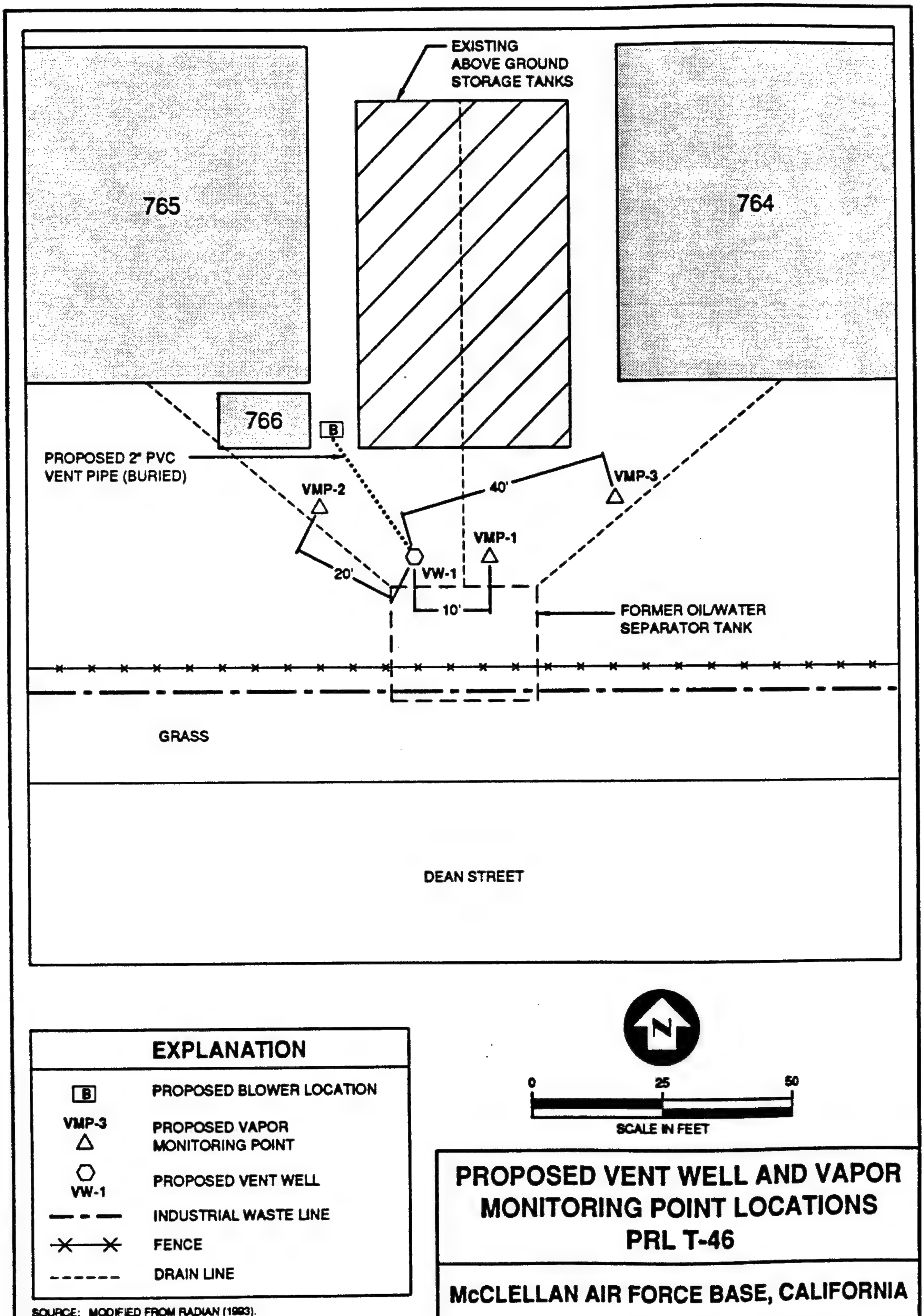
The radius of venting influence around the central VW is expected to be about 30 to 40 feet based upon the predominance of clays in subsurface soils at the site and upon the existence of significant contamination at a very shallow depth. The three VMPs are to be located at distances from the central VW which should provide adequate coverage over this expected radius of influence. Due to the lack of soil analytical data, a soil-gas reconnaissance will be performed in this area prior to VW/VMP installation. The soil-gas will be measured with a hand-held $O_2/CO_2$ meter to look for areas of soil-gas low in oxygen content which would indicate significant contamination.

### 3.1.6 Davis Site

Figure 3.6 shows the proposed location of the blower, the central VW, and the VMPs for the Davis Site. The VW location was chosen based upon the analytical results for soil boring B-3 and tank hold soil samples S4, S5, and S6, where the highest levels of contamination were found (see Figure 2.19 and Table 2.6). An existing vapor extraction well (CH-5) and two piezometers (P5-S and P5-D) are currently located at the site as part of recent soil vapor extraction pilot tests. In order to minimize drilling costs, these existing points will be used as VMPs during bioventing pilot testing where appropriate to estimate the radius of venting influence and biodegradation rates.

The radius of venting influence around the central VW is expected to be about 40 to 60 feet based upon the predominance of sands and silts in subsurface soils at the site and upon the expected depth of contamination at up to 60 feet. The two new VMPs are to be located at distances from the central VW which, along with the existing vapor monitoring points, should provide adequate coverage over the expected radius of influence.

FIGURE 3.4




**PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS PRL T-46**

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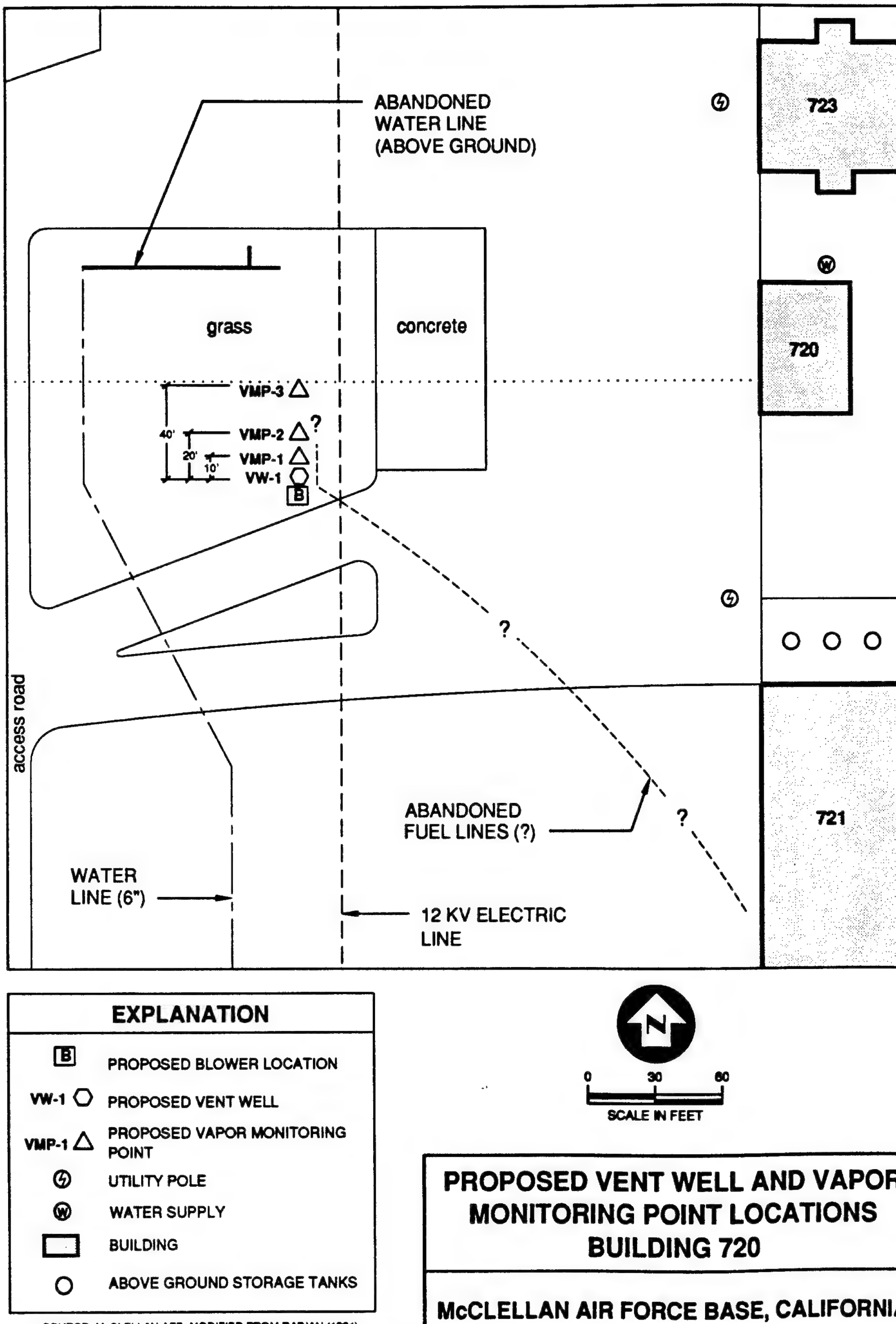


**PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS BUILDING 720**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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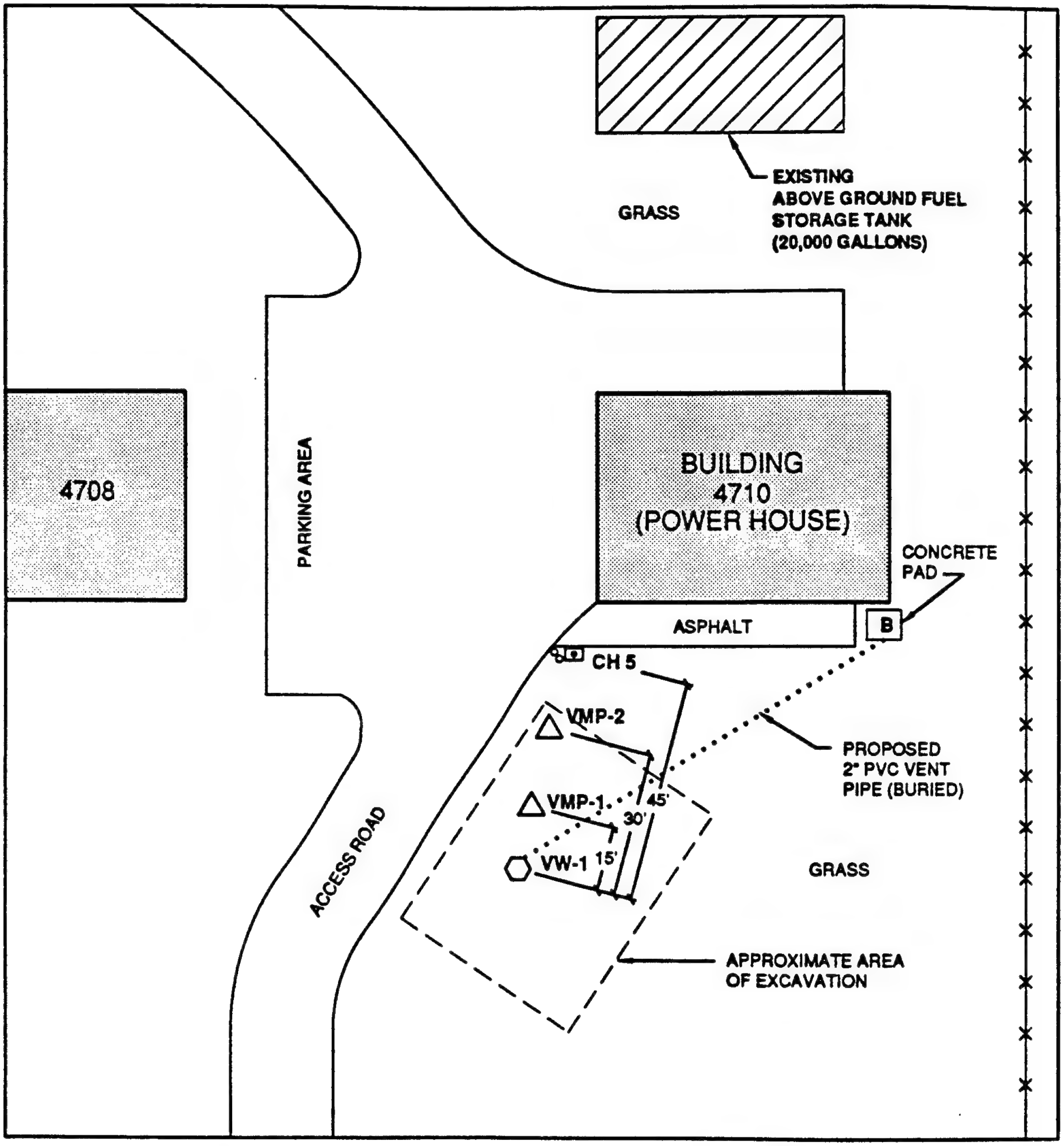
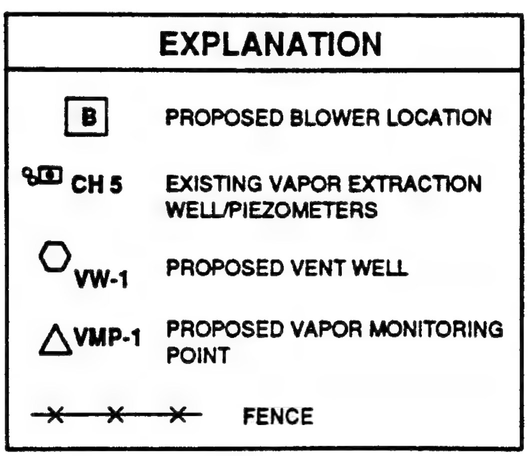
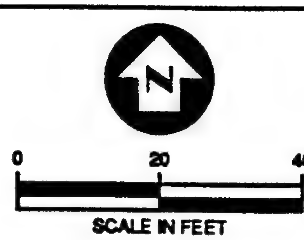
FIGURE 3.6




SOURCE: MODIFIED FROM CH2M HILL, 1993

**PROPOSED VENT WELL AND VAPOR MONITORING POINT LOCATIONS DAVIS SITE**

**DAVIS, CALIFORNIA**

REV. 2 C257-04.DWG 05/13/93

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### 3.1.7 Background VMPs

Up to three background VMPs will be installed as part of the initial pilot tests. The background VMPs will be used to measure background levels of oxygen and carbon dioxide and to determine if inorganic or natural carbon sources are contributing to the oxygen uptake during the *in situ* respiration test (described in Section 3.8).

One background VMP will be installed near the border of OUB and OUC, near the existing base fire department (Building 720). This location is not within any known contaminated area (Figure 3.7).

If necessary, an alternate background VMP may be installed in OUA (Figure 3.8). This alternate background VMP will be installed if contamination is discovered during the drilling of the primary background VMP or characterization of base soils requires greater geographic coverage for the background points.

The primary background VMP location for the Davis Site is shown in Figure 3.9. The location is outside the area of known soil and groundwater contamination and is approximately 1000 feet northeast of the UFST excavation.

## 3.2 Construction of Vent Wells

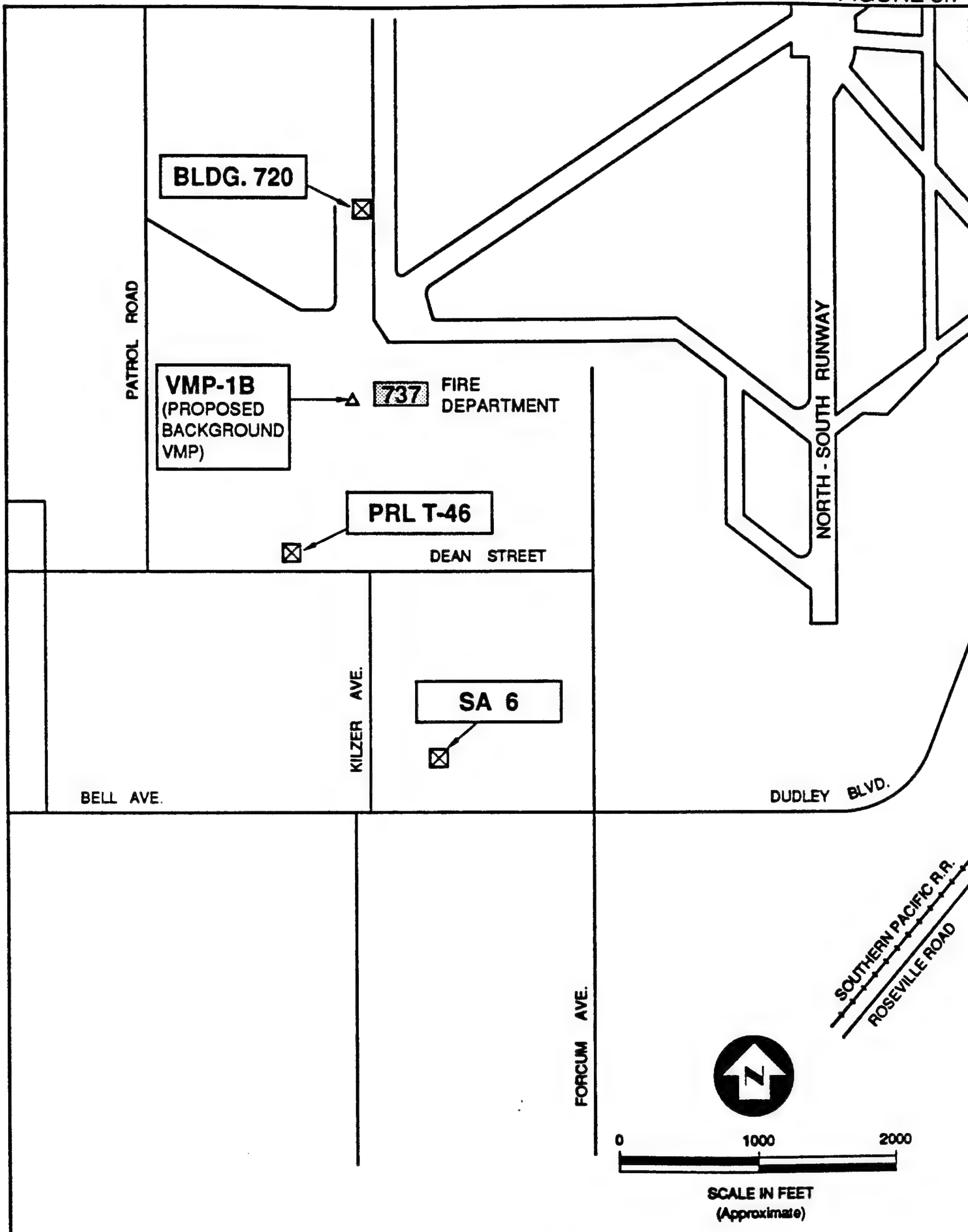
A typical construction diagram for the central VW at each site is shown in Figure 3.10. The central VW will be constructed of 4-inch ID schedule 40 PVC casing, with an interval of 0.04-inch slotted screen typically set between the initially encountered contamination (but a minimum of 5 feet bgs) down to the base of contamination as determined by field organic vapor analysis (OVA) of soil sample head space. The start of the screen interval may be set lower than the uppermost zone of soil contamination to prevent short-circuiting of injected air within any excavation fill material. A 100 ppmv OVA reading will be the criterion used in determining the selected depths. A GasTech™ Total Hydrocarbon Vapor Analyzer (THVA) will be used to collect field OVA readings. This platinum catalyst combustion detector is calibrated with hexane, which provides a conservative reading representative of total petroleum hydrocarbon vapors present.

Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack will be clean Lone Star sand with a 6-12 grain size and will be placed in the annular space of the screened interval. A 3-foot layer of bentonite will be placed directly over the filter pack. The remainder of the annular space, except for a 2-foot open area directly below the ground surface, will be filled with a bentonite/cement grout. A complete seal is critical to prevent the short circuiting of air to the surface during injection.

During extended pilot testing, the blower will be connected to the VW through 2-inch PVC pipe buried approximately 1 foot below the ground surface.

Additional details on VW construction are found in Section 4 of the protocol document.

FIGURE 3.7




SOURCE: Modified from McClellan AFB

**LOCATION OF PROPOSED BACKGROUND VMP**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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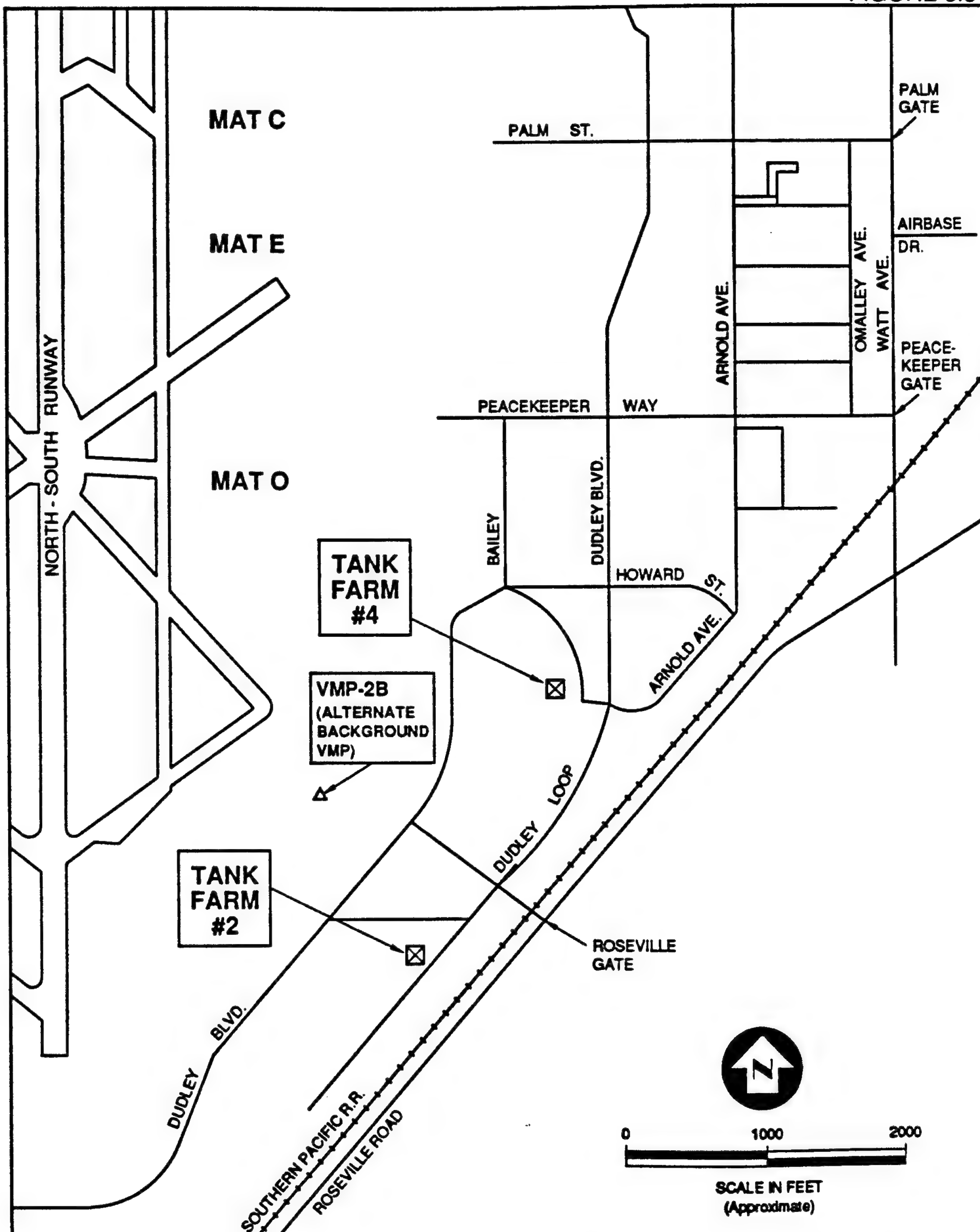
FIGURE 3.8

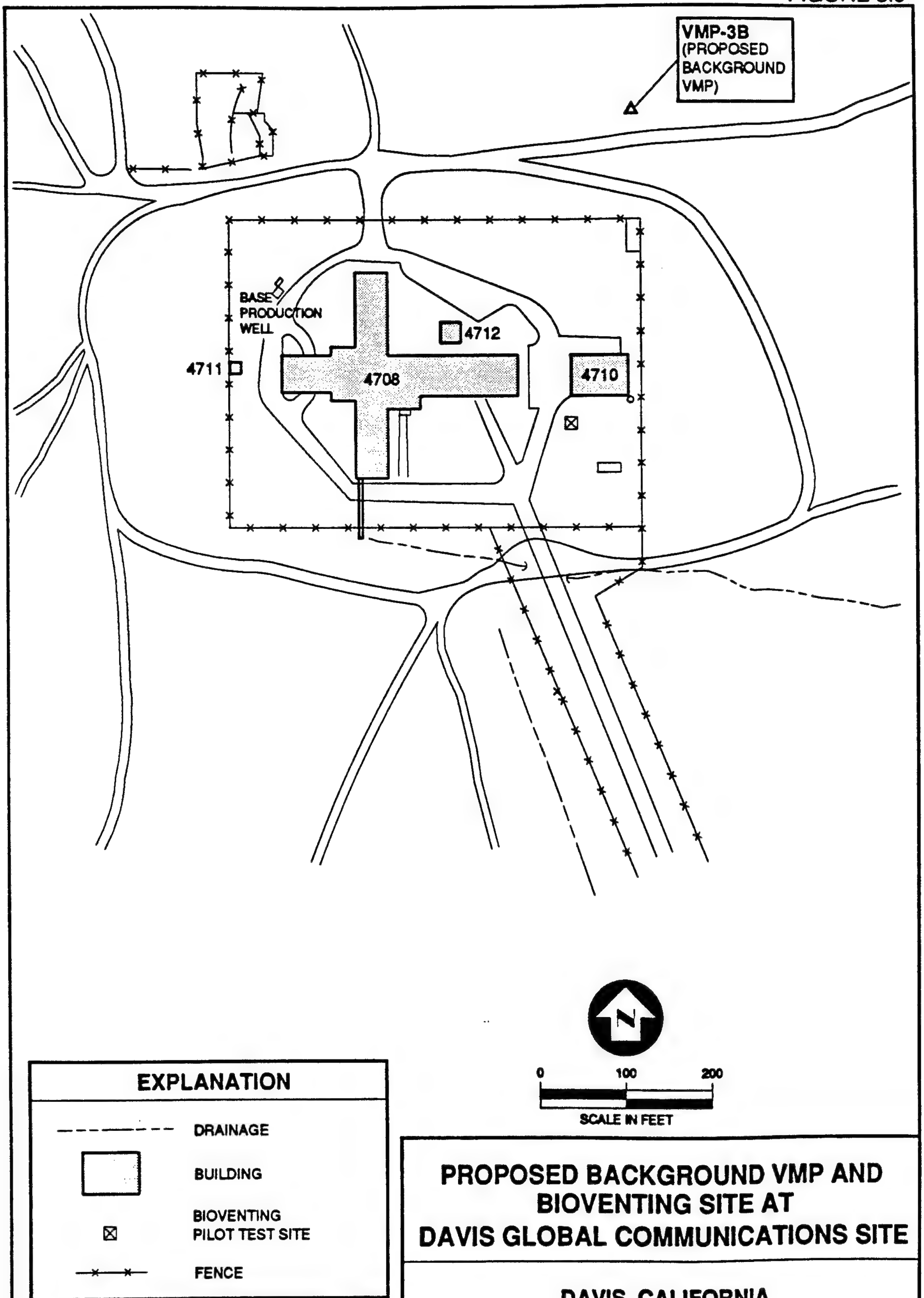



# LOCATION OF ALTERNATE BACKGROUND VMP

## McCLELLAN AIR FORCE BASE, CALIFORNIA

SOURCE: Modified from McClellan AFB

FIGURE 3.9




SOURCE: Modified from I T Corporation, 1992

**PROPOSED BACKGROUND VMP AND BIOVENTING SITE AT DAVIS GLOBAL COMMUNICATIONS SITE**

**DAVIS, CALIFORNIA**

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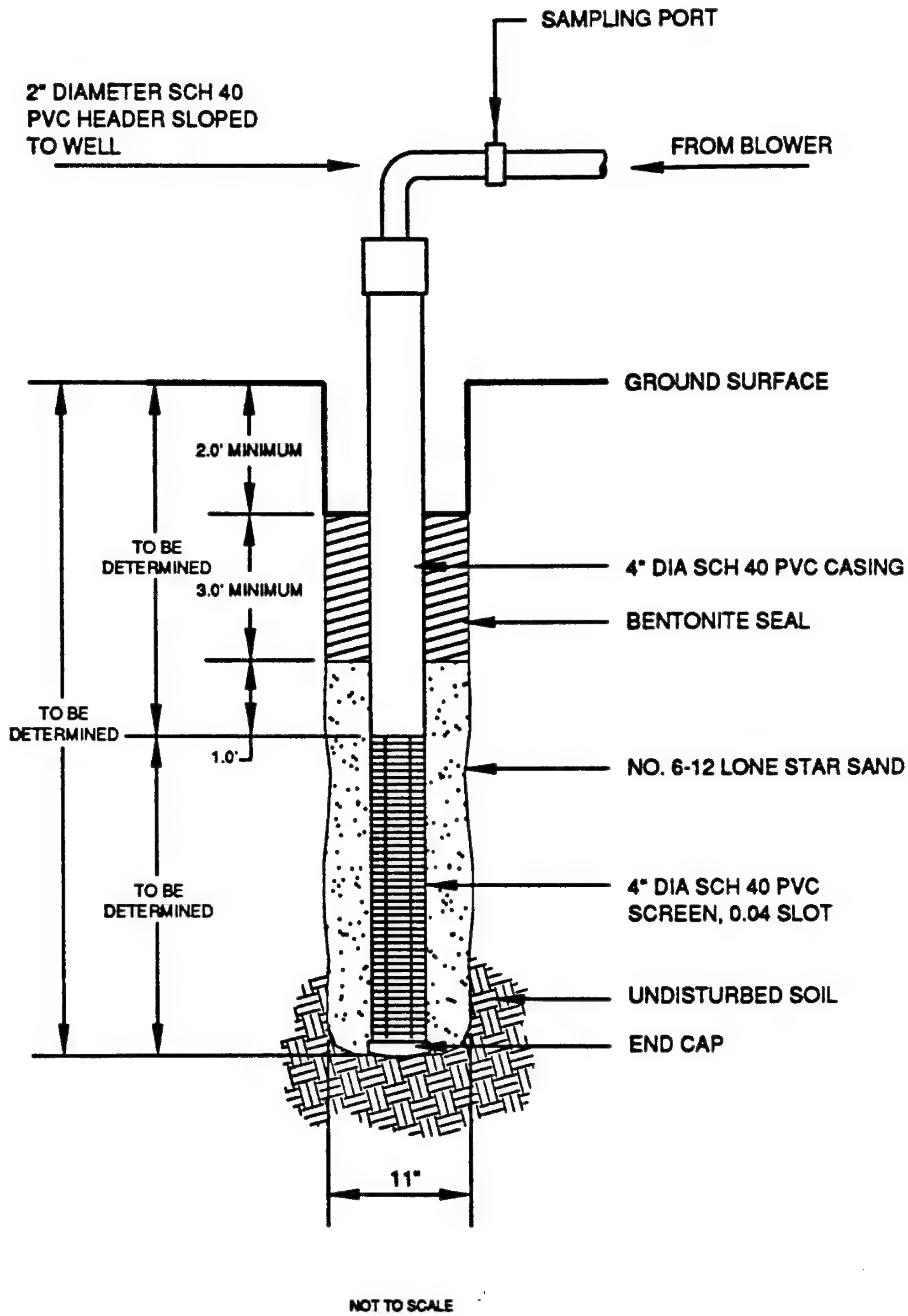
FIGURE 3.10




NOTE: DEPTH OF SCREENED INTERVAL WILL BE NEAR THE BASE OF CONTAMINATION AS DETERMINED IN THE FIELD.

DURING LONG-TERM BIOVENTING TEST, WELL WILL BE CONNECTED TO BLOWER VIA BURIED VENT PIPE.

**VENTING WELL CONSTRUCTION DIAGRAM (TYPICAL)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

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## 3.3 Construction of Vapor Monitoring Points

A typical construction diagram for the multi-depth VMPs at each site is shown in Figure 3.11. Soil-gas oxygen and carbon dioxide concentrations will be monitored via vapor monitoring screens placed at depth intervals which provide good vertical coverage between the ground surface and the base of contamination. Multi-depth monitoring will determine the concentration of oxygen across the entire soil profile and will be used to calculate oxygen utilization rates and fuel biodegradation rates at all monitored depths. The annular space between the vapor monitoring screen filter packs will be sealed with bentonite to isolate the monitoring intervals. As with the central VW, several inches of bentonite pellets will be used to shield the filter pack intervals from rapid infiltration of bentonite slurry additions. At the innermost vapor monitoring point (VMP-1), thermocouples will be installed at the same depths as the deepest and shallowest screens to measure soil temperature.

Additional details on VMP construction are found in Section 4 of the protocol document.

## 3.4 Handling of Drill Cuttings

All drill cuttings will be gathered after each borehole is drilled and containerized at each site in labelled U.S. DOT-approved 55 gallon drums. These soils will be handled according to protocol outlined in the base Soil Management Plan.

## 3.5 Soil and Soil-Gas Sampling

### 3.5.1 Soil Sampling

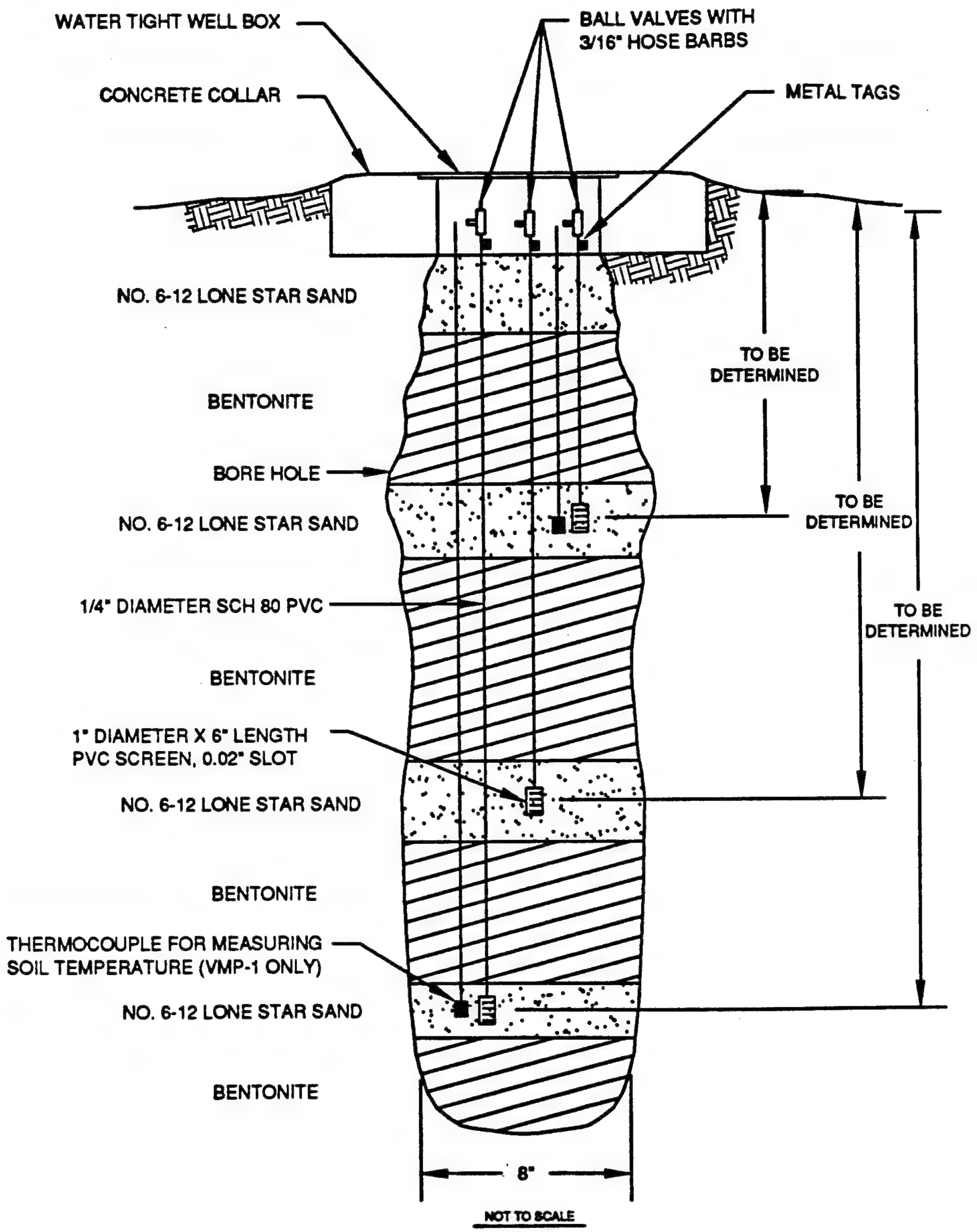
Three soil samples will be collected from each site during the installation of the central VW and VMPs. One sample will be collected from the interval of highest apparent contamination in the central VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the two innermost borings (VMP-1 and VMP-2). Soil samples will be analyzed for total recoverable petroleum hydrocarbons (TRPH), benzene, toluene, ethylbenzene, and xylenes (BTEX), moisture content, pH, grain size distribution, total alkalinity, iron, and nutrients including total Kjeldahl nitrogen (TKN) and total phosphorus.

At sites where significant gasoline contamination is expected (Tank Farm #4 and SA 6), soil samples will be analyzed for purgeable total petroleum hydrocarbons as gasoline (TPH-g) instead of TRPH. At the Davis Site, where soil may potentially be contaminated by halogenated VOCs in addition to fuel residuals, soil samples will also be analyzed for halogenated VOCs (EPA Method 8010).

Additional soil samples will be collected at each of the background VMPs and analyzed for TKN to help characterize the non-contaminated, baseline soil nutrient conditions.

Soil samples will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes will be immediately trimmed and the ends sealed with Teflon® fabric held in place by plastic caps. Soil samples collected for

FIGURE 3.11




NOTE: AN ADDITIONAL VMP SCREEN MAY BE INSTALLED NEAR THE BASE OF CONTAMINATION (AS DETERMINED IN THE FIELD).

**VAPOR MONITORING POINT CONSTRUCTION DIAGRAM (TYPICAL)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 2 C257-02.DWG 05/13/93

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inorganic and physical parameters analysis will be collected in brass tubes or placed in other appropriate sample containers. Soil samples will be labeled following the nomenclature specified in Section 5.5 of the protocol document, wrapped in plastic, and placed in an ice chest for shipment. A chain-of-custody form will be filled out and the ice chest shipped for analysis to a laboratory that has been audited by the U.S. Air Force and which meets all quality assurance/quality control and certification requirements for the State of California.

### 3.5.2 Soil-Gas Sampling

A total hydrocarbon vapor analyzer (THVA) (refer to Section 4.5.2 of the protocol document) will be used to screen split-spoon samples during drilling for determination of the most contaminated intervals. During the pilot test at each site, initial and final soil-gas samples at each site will be collected in Summa® cannisters from the central VW (VW-1) and the VMPs closest to and furthest from the central VW (VMP-1 and VMP-3). These soil-gas samples will be used to predict potential air emissions and to determine the reduction in BTEX and total hydrocarbons.

Soil-gas samples will be placed in an ice chest and packed to prevent excessive movement during shipment. Samples will not be sent on ice in order to prevent condensation of hydrocarbons. Samples will be analyzed for BTEX and total volatile hydrocarbons (TVH) using EPA Method TO-3. At the Davis Site, where the soil is contaminated with numerous other VOCs in addition to fuel residuals, the samples will also be analyzed by EPA Method TO-14. A chain-of-custody form will be filled out and the ice chest shipped to the Air Toxics Laboratory in Rancho Cordova, California for analysis.

### 3.5.3 Potential Air Emissions Monitoring

In order to characterize potential air emissions during the pilot test, soil-gas samples will also be taken at the ground surface for the two sites not covered by asphalt or concrete (Tank Farm #2 and the Davis Site). Total volatile hydrocarbons (TVH) will be measured at the ground surface before and during air injection at 9 locations at each of the sites. The measurement locations will be arranged around the injection well radiating outward in three arms of three points each, spaced roughly 120° apart and long enough to fully characterize the expected radius of influence.

Hydrocarbon emissions will be measured using both field and laboratory analysis. TVH will be measured in the field by placing a flux chamber on the ground surface and then withdrawing soil-gas samples at a rate of approximately one liter per minute into the GasTech™ Total Hydrocarbon Vapor Analyzer (THVA). This platinum catalyst combustion detector is calibrated with hexane, which provides a conservative reading representative of total petroleum hydrocarbon vapors present. The air in the flux chamber will be sampled continuously for a period of five minutes at each location, before and during air injection, and the readings will be recorded in the field notebook.

To further characterize the fuel hydrocarbon and BTEX content of the soil-gas emissions, two soil-gas samples will be taken from a monitoring location located at one-third of the distance of the outermost VMP from the central VW. Samples will be taken

prior to air injection and after four hours of air injection. These samples will be collected for laboratory analyses using an evacuated, one liter Summa® cannister to draw a sample from the flux chamber. The samples will be shipped and analyzed as described in Section 3.5.2.

### 3.6 Blower System

A 3.0 horsepower, portable, positive displacement blower capable of injecting air at approximately 30 standard cubic feet per minute (scfm) at 4 psi (110 inches $H_2O$) will be used to conduct the initial air permeability test at each site. Figure 3.12 is a schematic of a typical air injection system used for pilot testing. The maximum power requirement anticipated for pilot testing is 230 volt, single-phase, 30 amp service.

Additional details on power supply requirements are described in Section 5.0, Base Support Requirements.

### 3.7 Air Permeability Tests

The objective of the air permeability test is to determine the extent of the subsurface which can be oxygenated using one air injection unit. Air will be injected into the 4-inch diameter central VW at each site using the portable blower unit, and the pressure response will be measured at each VMP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the VMPs to ascertain that oxygen levels in the soil increase as a result of air injection. One air permeability test lasting approximately 8 hours will be conducted at each site.

Additional details on the air permeability test are found in Section 5.6 of the protocol document.

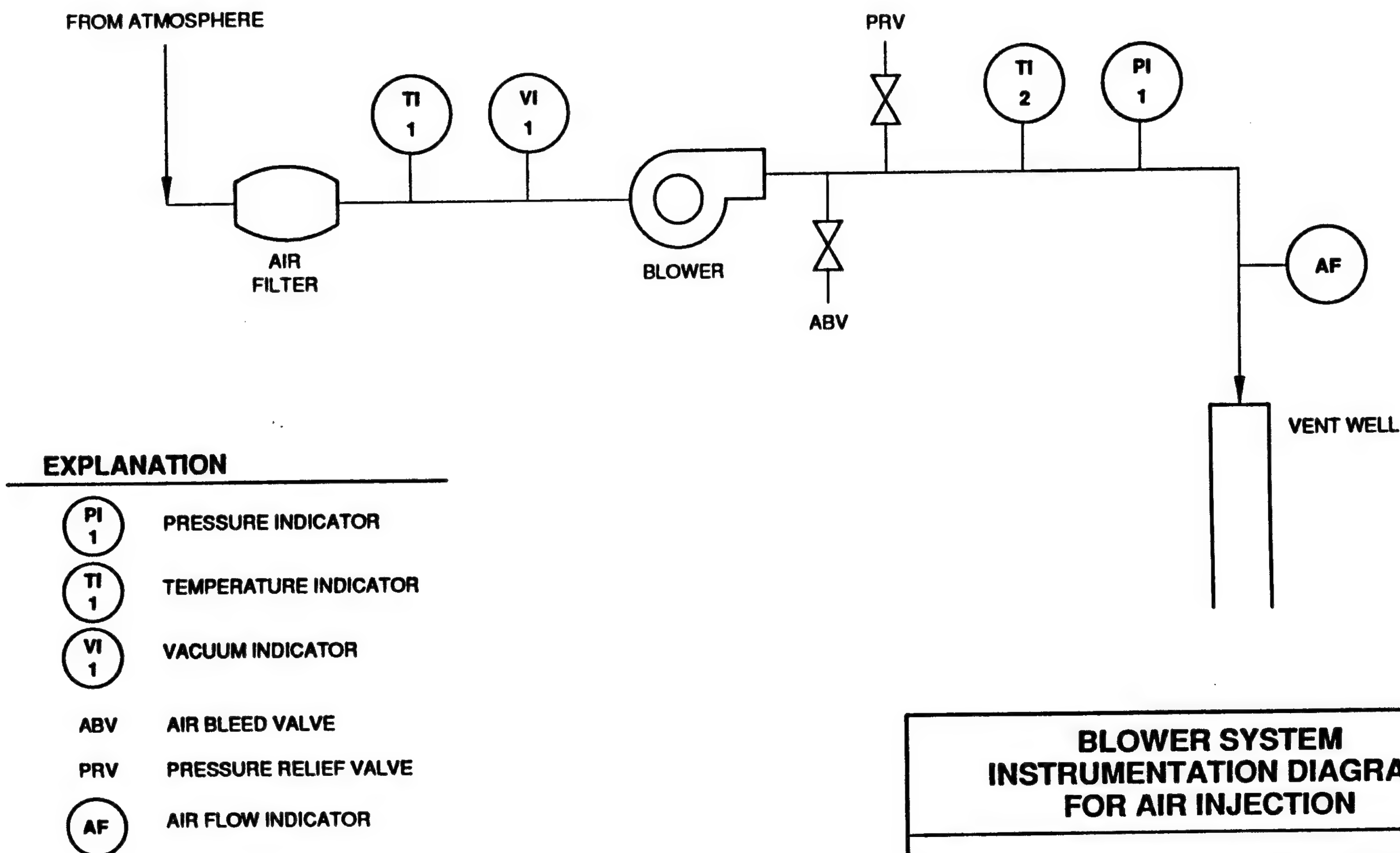
### 3.8 *In Situ* Respiration Tests

The objective of the *in situ* respiration test is to determine the rate at which soil bacteria will biodegrade the TPH contamination in the soil. At each site, respiration tests will be performed at vapor monitoring screens where bacterial degradation is indicated by initially low oxygen levels and elevated carbon dioxide levels in the soil gas. Air will be injected at points containing low oxygen levels (below approximately 2 percent) for approximately 20 hours to oxygenate local contaminated soils. At the end of the 20-hour period, the air supply will be cut off and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen levels and increase in carbon dioxide levels over time will be used to estimate rates of bacterial degradation of fuel residuals.

Respiration tests will also be conducted at any background VMP which shows initial oxygen levels below 18% in order to correct biodegradation rates for inorganic or natural carbon source uptake of oxygen.

Helium, an inert gas, will be injected at a concentration of 2 to 4 percent into vapor monitoring points used for respiration testing. Helium levels will be monitored during the respiration test to identify possible system leaks or short circuits to the surface.

FIGURE 3.12




**BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 2 C257-03.DWG 05/13/93

ENGINEERING-SCIENCE, INC.

Additional details on *in situ* respiration testing are found in Section 5.7 of the protocol document.

### 3.9 Installation of Extended Bioventing Pilot Test Systems

An extended (one-year) bioventing pilot test system will be implemented at each site if the initial pilot test successfully demonstrates the feasibility of providing oxygen throughout the contaminated soil profile. This one year of continuous air injection will determine the long-term radius of influence, and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates. A fixed Gast™ regenerative blower unit, sized appropriately for each site, will be installed as part of this extended pilot test system. The blower will be housed in a small shed to provide protection from the weather and to minimize noise. This small "doghouse" will be located in a low-traffic area. Base personnel are required to check the blower systems once each week to ensure that they are all operating and to record air injection pressures, flow rates, and temperatures. ES will provide a maintenance procedures manual, data collection sheets, and a brief training session.

At the SA 6 site, the blower used for the extended pilot test system may be sized and installed to vent into two vent wells if the initial pilot test results are favorable. At the remaining five sites only one vent well will be used.

The systems will be in operation for one year, and ES personnel will monitor them biannually, scheduled for March 1994 and September 1994. This biannual monitoring will consist of *in situ* respiration tests at each site to monitor the long-term performance of the bioventing systems. At the end of the extended (one-year) test, subsurface soil samples will be collected and analyzed at locations as close as possible to the original VW/VMP soil sample locations at each site. Additionally, at the end of the extended test, soil-gas samples will be collected and analyzed from the same VMP screens sampled during the initial pilot test. These soil and soil-gas samples will be used to assess the degree of remediation during the first year of *in situ* treatment.

## 4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used at each site to construct wells, measure air permeability of the soil, and conduct the *in situ* respiration tests are described in Section 4 and 5 of the protocol document. No exceptions to the protocol are anticipated.

## 5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of a driller and the ES test team:

- Obtaining all necessary regulatory permits for the vent well and vapor monitoring points, and any air permits needed for pilot test approval.
- Obtaining a base digging permit.
- Installation of a 230V/single phase/30 amp breaker box with one 230V receptacle (NEMA type L630) and two 110V receptacles at each site. This breaker box must be within 20 feet of the proposed blower location at each site (Figures 3.1 through 3.6).
- Provide any paperwork required to obtain gate passes and security badges for approximately three ES employees and two drillers. Vehicle passes will be needed for two trucks and a drill rig. The passes must be valid for the expected duration of the six initial pilot tests (about eight weeks).
- Provide keys to any on-site groundwater monitoring wells.

During the initial pilot tests (an eight week period), the following base support is required:

- Twelve square feet of desk space and use of a telephone at both McClellan AFB and the Davis Site.
- The use of a fax machine for transmitting test results.
- A decontamination area where the driller can clean augers between borings.

During the extended (one-year) pilot test, the following base support is required:

- Base personnel are required to check the blower systems once each week to ensure that they are all operating and to record air injection pressures, flow rates, and temperatures. ES will provide a maintenance procedures manual, data collection sheets, and a brief training session.
- If any blowers stop working, notify: Mr. Fred Stanin or Mr. Michael Phelps, ES-Alameda, (510) 769-0100; or Mr. Doug Downey, ES-Denver (303) 831-8100; or Mr. Patrick Haas of AFCEE, (210) 536-4314.
- Arrange for site access for ES technicians to conduct *in situ* respiration tests at approximately six months and one year after the initial pilot tests.

## 6.0 PROJECT SCHEDULE

The following schedule is contingent upon timely approval of this pilot test work plan.

| Event | Date |
|---|---|
| Initial Base Meeting | 10-11 February 1993 |
| Pilot Test Work Plan to AFCEE/McClellan AFB | 21 May 1993 |
| Approval to Proceed | 18 June 1993 |
| Begin VW and VMP construction | 21 June 1993 |
| Begin Initial Pilot Tests | 12 July 1993 |
| Completion of Initial Pilot Tests | 27 August 1993 |
| Interim Results Report | November 1993 |
| Biannual Respiration Tests | March 1994 |
| Final Respiration Tests and Soil Sampling | September 1994 |

## 7.0 POINTS OF CONTACT

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Fax (510) 769-9244

## 8.0 REFERENCES

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*Part II*

*Draft*
*Bioventing Pilot Test Interim Results Report for*

# Tank Farm #2, Tank Farm #4, SA 6, PRL T-46, Building 720 McCLELLAN AIR FORCE BASE, CALIFORNIA *and* Davis Global Communications Site DAVIS, CALIFORNIA

*Prepared for*

**Air Force Center for Environmental Excellence**
**Brooks AFB, Texas**
**and**
**Environmental Management**
**McClellan Air Force Base, California**

**February 1994**

*Prepared by*

**ENGINEERING-SCIENCE, INC.**
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*OFFICES IN PRINCIPAL CITIES*
*54-17A*

## TABLE OF CONTENTS

**Part II**
**DRAFT BIOVENTING PILOT TEST INTERIM RESULTS REPORT**
**FOR TANK FARM #2, TANK FARM #4, SA 6, PRL T-46, BUILDING 720**
**McClellan AFB, California**

**and**

**DAVIS GLOBAL COMMUNICATIONS SITE**
**Davis, California**

Page

## TABLE OF CONTENTS
## (continued)

## TABLE OF CONTENTS
## (continued)

Page

## TABLE OF CONTENTS
## (continued)

## LIST OF TABLES

## LIST OF TABLES (continued)

## LIST OF FIGURES

# PART II
# DRAFT BIOVENTING PILOT TEST INTERIM RESULTS REPORT
# FOR
# TANK FARM #2, TANK FARM #4, SA 6, PRL T-46, BUILDING 720
# McClellan AFB, California
# and
# DAVIS GLOBAL COMMUNICATIONS SITE
# Davis, California

Initial bioventing pilot tests were completed at one site at the Davis Global Communications Site (Davis Site) in Davis, California and four sites at McClellan Air Force Base, California (McClellan AFB): Tank Farm #2 (TF-2), Tank Farm #4 (TF-4), Study Area 6 (SA 6), and Potential Release Location T-46 (PRL T-46). Background vapor monitoring points were installed at the Base Fire Department and at the Davis Site. A single vapor monitoring point was installed at Building 720 on the base. The purpose of this Part II Interim Report is to describe the results of the initial pilot tests at each site and make specific recommendations for the extended (one-year) pilot tests which will determine the long-term impact of bioventing on site contaminants. Site histories, known contamination distributions and concentrations, and geologic/hydrogeologic profiles are documented in Part I, Bioventing Pilot Test Work Plan.

## 1.0 PILOT TEST DESIGN AND CONSTRUCTION

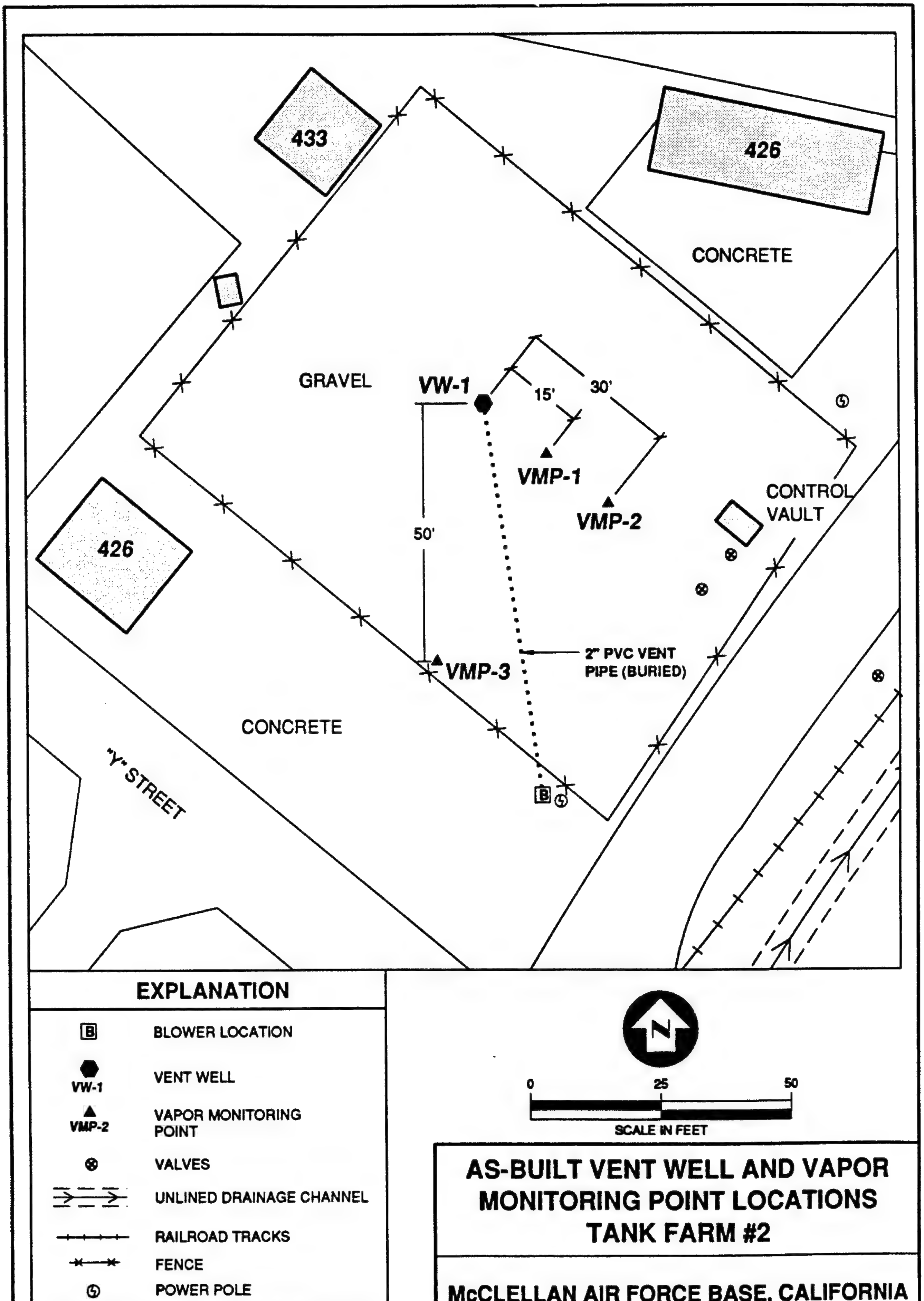
## 1.1 Tank Farm #2 (TF-2)

### 1.1.1 Introduction

Installation of one vent well (VW) and three vapor monitoring points (VMPs) was conducted at the TF-2 site between 6 and 12 July 1993. Locations of the VWs and VMPs are shown on Figure 1.1. Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Mr. Henry Pietropaoli of the Engineering-Science, Inc. (ES) office in Alameda, California.

Four boreholes were drilled at the site and all were converted to either a VW or a VMP. No boreholes were abandoned since contamination observed during drilling was at sufficient levels for VW and VMP siting. Soil samples from split-spoon and/or continuous soil samplers were collected for field organic vapor analysis (OVA) to determine appropriate VW and VMP screened intervals and total depths. Both a total hydrocarbon vapor analyzer (THVA) and a photoionization detector (PID) were used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.1 summarizes pertinent borehole data.

FIGURE 1.1




SOURCE: MODIFIED FROM JACOBS ENGINEERING, 1992

## AS-BUILT VENT WELL AND VAPOR MONITORING POINT LOCATIONS TANK FARM #2

McCLELLAN AIR FORCE BASE, CALIFORNIA

REV. 4 C257-18.DWG 11/10/93

ENGINEERING-SCIENCE, INC.

# TABLE 1.1
# BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
## Tank Farm #2
## McClellan AFB, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 40.0 | 2.5 – 5.0 | 8/32 | | 7/6/93 | 7/9/93 | VW–1 |
| | | 7.5– 10.0 | 420/1176 | | | | |
| | | 15.0 – 17.5 | 2200/6536 | | | | |
| | | 20.0 – 22.5 | >10,000/6077 | TF2–VW1–22.5 | | | |
| | | 25.0 – 27.5 | 1500/2246 | | | | |
| | | 27.5 – 30.0 | 22/108 | | | | |
| | | 32.5 – 35.0 | 26/89 | | | | |
| | | 37.5 – 40.0 | 40/72 | | | | |
| 2 | 50.0 | 2.5 – 5.0 | 2/9.8 | | 7/7/93 | 7/9/93 | VMP–1 |
| | | 12.5 – 15.0 | 820/906 | | | | |
| | | 17.5 – 20.0 | 9000/4860 | TF2–VMP1–20 | | | |
| | | 22.5 – 25.0 | 400/685 | | | | |
| | | 27.5 – 30.0 | 8/134 | | | | |
| | | 32.5 – 35.0 | 0/69 | | | | |
| | | 37.5 – 40.0 | 22/108 | | | | |
| | | 42.5 – 45.0 | 8/52 | | | | |
| | | 47.5 – 50.0 | 17/86 | | | | |
| 3 | 45.0 | 2.5 – 5.0 | 1/8.9 | | 7/8/93 | 7/12/93 | VMP–2 |
| | | 7.5 – 10.0 | 550/428 | | | | |
| | | 12.5 – 15.0 | 1700/2010 | | | | |
| | | 20.0 – 22.5 | 2200/924 | TF2–VMP2–21 | | | |
| | | 22.5 – 25.0 | 170/304 | | | | |
| | | 27.5 – 30.0 | 180/497 | | | | |
| | | 32.5 – 35.0 | 520/1115 | | | | |
| | | 37.5 – 40.0 | 10/140 | | | | |
| | | 42.5 – 45.0 | 12/81 | | | | |
| 4 | 40.0 | 2.5 – 5.0 | 8/18.6 | | 7/8/93 | 7/12/93 | VMP–3 |
| | | 7.5 – 10.0 | >10,000/6246 | | | | |
| | | 12.5 – 15.0 | 5500/7131 | | | | |
| | | 17.5 – 20.0 | 6500/6313 | | | | |
| | | 22.5 – 25.0 | 240/212 | | | | |
| | | 27.5 – 30.0 | 130/117 | | | | |
| | | 32.5 – 35.0 | 42/54 | | | | |
| | | 37.5 – 40.0 | 11/24 | | | | |

01/06/94
TF2TAB1.WKJ

### 1.1.2 Soil Profile

Figure 1.2 is a geologic cross-section of the pilot test site using data from the VW and three VMPs. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TRPH concentrations from laboratory analysis of soil samples, and initial oxygen levels in soil gas. The soil boring logs are included in Appendix A.

Below the 6-inch layer of surface gravels, the observed soil profile down to about 12 feet below ground surface (bgs) in VW-1 and VMP-3, and 17 feet bgs in VMP-1 and VMP-2, is a dark-brown to red-brown silty clay material. This material is interpreted to be backfill material from the previous 1992 underground storage tank (UST) excavation. This interval exhibited a noticeable fuel odor in all boreholes. A predominantly greenish-yellow to blue-green clayey silt interval underlies the silty clay fill to approximately 21 feet bgs in all borings. The soil profile for VMP-3 exhibits an additional layer of green-yellow clayey sand from 15 to 17 feet bgs, within the clayey silt.

An interval of primarily green to brown clayey sand exists from 21 feet bgs to a depth of approximately 40 feet bgs in soil profiles for VW-1, VMP-1, and VMP-2. This interval was found to be underlain by red-brown to tan-brown silty clay, which continues to the base of all three boreholes.

The soil profile for VMP-3 exhibits the same green to brown clayey sand to a depth of 28 feet bgs, where the lithology changes to a sandy, silty clay which continues to the base of the borehole, where a three-foot lens of well sorted silty sand occurs from 36 to 39 feet bgs.

Contamination was observed in all boreholes in the form of fuel odors to depths of approximately 21 feet bgs. Blue-green discoloration was noted in VMP-2 and VMP-3 at depths near the highest OVA readings. Additional sweet odors were noted to a maximum depth of 35 feet bgs, occurring in VMP-2.

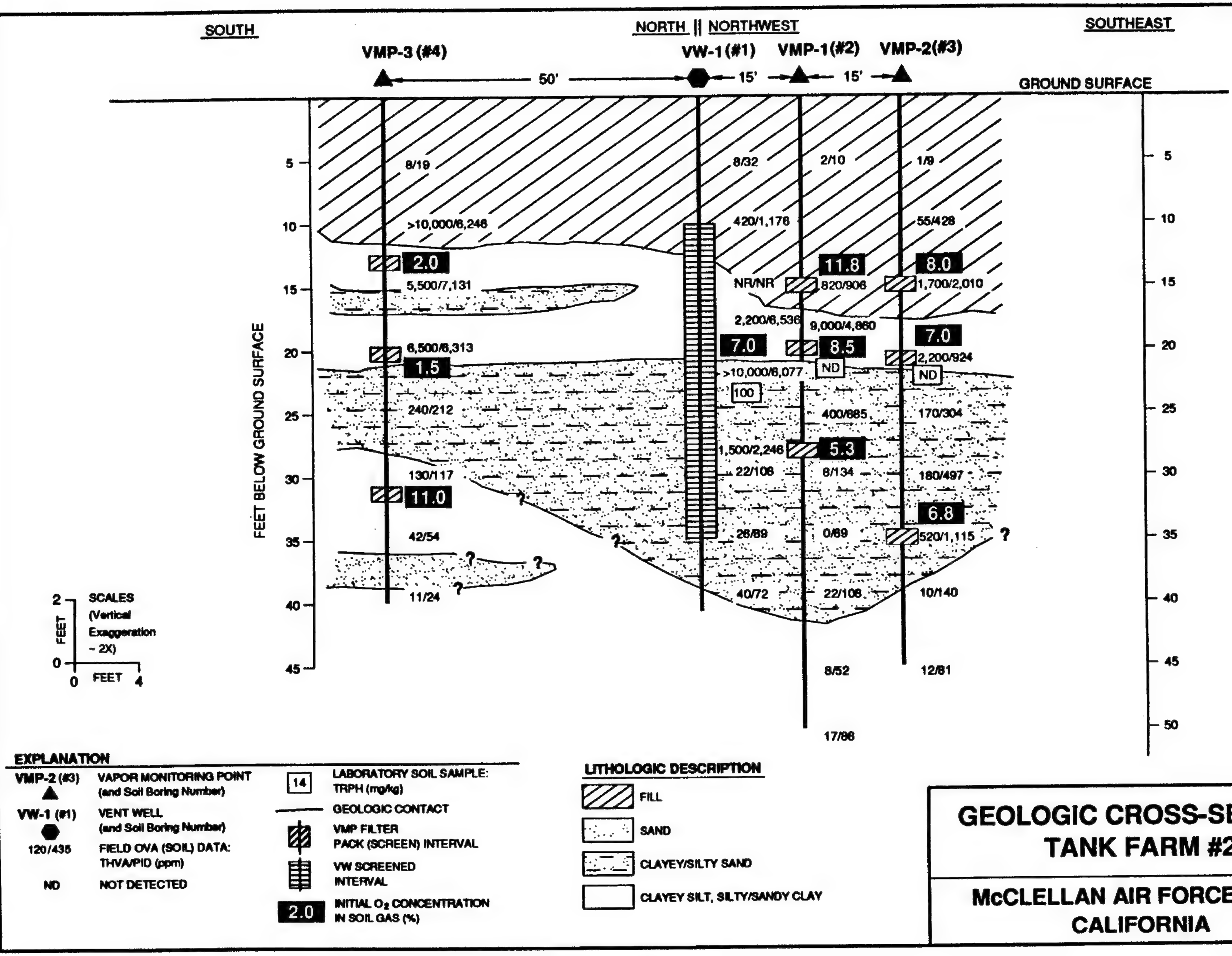
Groundwater was not encountered in any of the borings at the site.

### 1.1.3 Air Injection Vent Well

One air injection VW (VW-1) was installed in a location where soils exhibited a noticeable fuel odor following procedures described in the protocol document (Hinchee et al., 1992). VW-1 was installed approximately 40 feet south of the north boundary and 40 feet west of the east boundary of the site, near the former location of the underground storage tanks (Figure 1.1). Table 1.2 presents construction data, and Figure 1.3 shows construction details for the VW.

VW-1 was constructed using 4-inch inside diameter (ID), Schedule 40 PVC casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with size 6-12 Lone Star sand (filter pack material) from 35 feet bgs to approximately 2 feet above the top of the screen. A small amount of size 1-C Lone Star sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval.

To prevent preferential air movement near the surface during pilot testing, a 2-foot thick annular bentonite seal was emplaced on top of the filter pack. The annulus of the




# GEOLOGIC CROSS-SECTION TANK FARM #2

## McCLELLAN AIR FORCE BASE, CALIFORNIA

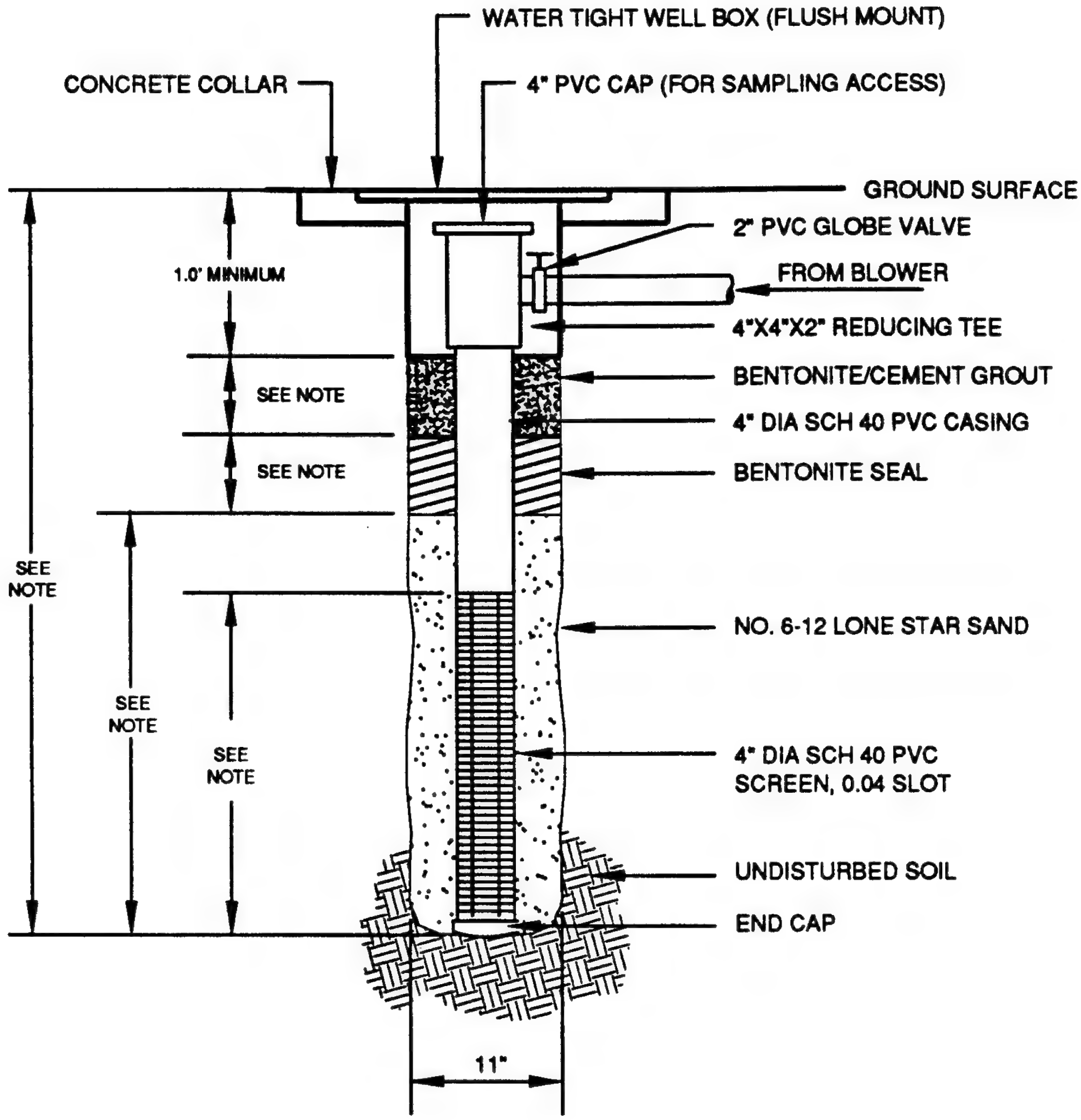
REV. 4 C258-40.DWG 02/09/94

# TABLE 1.2
# VMP/VW CONSTRUCTION DATA
## Tank Farm #2
## McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VW-1 | 40.0 | 10 – 35 | – | 7.5 – 35.5 | 5.5 – 7.5 | 2.0 – 5.5 |
| | | | | | 35.5–40.0 | |
| VMP-1 | 50.0 | – | 15.0 | 14.5 – 15.5 | 3.5 – 14.5 | None |
| | | | 20.0 | 19.5 – 20.5 | 15.5 – 19.5 | |
| | | | 28.0 | 27.5 – 28.5 | 20.5 – 27.5 | |
| | | | | | 28.5 – 50.0 | |
| VMP-2 | 45.0 | – | 15.0 | 14.5 – 15.5 | 4.0 – 14.5 | None |
| | | | 21.0 | 20.5 – 21.5 | 15.5 – 20.5 | |
| | | | 35.0 | 34.5 – 35.5 | 21.5 – 34.5 | |
| | | | | | 35.5 – 45.0 | |
| VMP-3 | 40.0 | – | 13.0 | 12.5 – 13.5 | 4.0 – 12.5 | None |
| | | | 20.0 | 19.5 – 20.5 | 13.5 – 19.5 | |
| | | | 32.0 | 31.5 – 32.5 | 20.5 – 31.5 | |
| | | | | | 32.5 – 40.0 | |

01/18/94

TF2TAB2.WK1




NOTE: WELL CONSTRUCTION DETAILS CAN BE FOUND IN FOLLOWING TABLES.

| SITE | WELL DETAILS |
|---|---|
| TANK FARM # 2 | TABLE 1.2 |
| TANK FARM # 4 | TABLE 1.4 |
| SA 6 | TABLE 1.6 |
| PRL T-46 | TABLE 1.8 |
| BUILDING 720 | TABLE 1.10 |
| BASE FIRE DEPT. | TABLE 1.12 |
| DAVIS SITE | TABLE 1.14 |

**VENTING WELL CONSTRUCTION DIAGRAM (TYPICAL)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 5 C258-29.DWG 01/20/94

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well was then filled with a bentonite/cement grout to approximately 2 feet bgs. The upper 1.5 feet of annular space was left vacant for ease of connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The upper 2 feet of well casing was completed with a 4-inch diameter Schedule 40 PVC tee and a 4-inch PVC cap. The tee was connected to the 2-inch diameter PVC pipe from the blower unit and fitted with a flow control valve to isolate the VW for sampling purposes. The surface completion of the VW consisted of a water-tight, traffic-proof, cast-iron well box (securable with hexbolts) emplaced within a 3-foot diameter concrete collar sloped away from the box for drainage.

VW-1 was connected to the blower unit by 2-inch diameter Schedule 40 PVC pipe buried in a trench. The trench, approximately 75 feet long, 4 inches wide, and 1 foot deep, was excavated from the blower location to VW-1, and PVC pipe was laid in the trench. After securing the pipe, soil was returned to the trench and compacted. The horizontal pipe was elbowed below ground at the designated blower location and the top of the vertical PVC pipe was cut to approximately two feet above ground surface. The above ground PVC pipe was connected directly to the portable blower unit for the initial pilot test and then to the fixed blower unit for the extended pilot test.

### 1.1.4 Vapor Monitoring Points

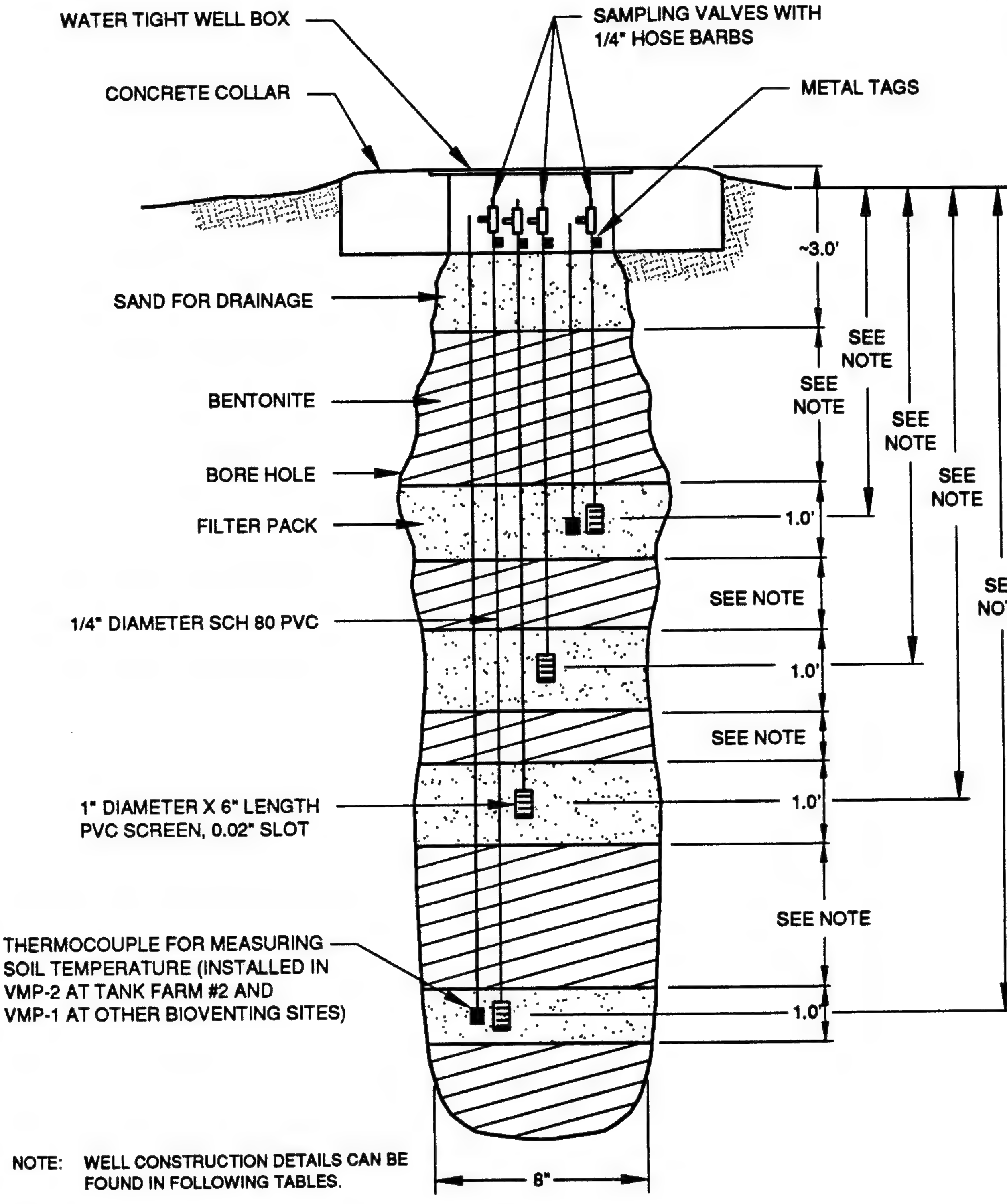
VMP-1 and VMP-2 were installed in a line southeast of VW-1, generally following the direction of the former USTs, at distances of 15 feet and 30 feet from the VW, respectively. VMP-3 was installed adjacent to the southwest site boundary at a distance of 49 feet south of VW-1 (Figure 1.1).

All VMPs were installed following procedures described in the protocol document. Table 1.2 presents construction data, and Figure 1.4 shows construction details for the VMPs. All three VMPs have nearly identical construction details with only slight variations in actual screened intervals. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Three casing strings/screens were installed in each VMP borehole to provide monitoring points at variable depths, soil types, and contamination levels. The center of the screened intervals for each VMP are located as follows: 15, 20 and 28 feet bgs for VMP-1; 15, 21 and 35 feet bgs for VMP-2; and 13, 20 and 32 feet bgs for VMP-3.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and was centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-2, two thermocouples were installed adjacent to screens at depths of 15 and 35 feet bgs to allow measurement of soil temperature. The surface of each VMP was completed with a flush-mount well box similar to the VW surface completion.

### 1.1.5 Blower Units

A portable 3.0-horsepower (HP) Roots™ positive displacement blower unit was used for the initial pilot test, powered by an on site 230-volt (V), single-phase, 30-amp (A) line




NOTE: WELL CONSTRUCTION DETAILS CAN BE FOUND IN FOLLOWING TABLES.

| SITE | WELL DETAILS |
|---|---|
| TANK FARM # 2 | TABLE 1.2 |
| TANK FARM # 4 | TABLE 1.4 |
| SA 6 | TABLE 1.6 |
| PRL T-46 | TABLE 1.8 |
| BUILDING 720 | TABLE 1.10 |
| BASE FIRE DEPT. | TABLE 1.12 |
| DAVIS SITE | TABLE 1.14 |

**AS-BUILT VAPOR MONITORING POINT CONSTRUCTION DETAIL (TYPICAL)**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 5 C242-08.DWG 02/09/94

ENGINEERING-SCIENCE, INC.

provided by the base. A fixed 1.0-HP Gast™ regenerative blower unit (model R4) was installed and began operation on 29 July 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power pole and blower are shown on Figure 1.1.

At the time of installation, the fixed blower unit was injecting approximately 50 standard cubic feet per minute (scfm) for the extended pilot test. Figure 1.5 shows the process flow and instrumentation diagram for this system. ES personnel provided an operations and maintenance (O&M) data collection sheet and blower maintenance manual to base personnel. A sample copy of the data collection sheet and maintenance manual is provided in Appendix B.

### 1.1.6 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.
- Thermocouples were installed in VMP-2 instead of VMP-1.

## 1.2 Tank Farm #4 (TF-4)

### 1.2.1 Introduction

Installation of one VW and three VMPs was conducted at TF-4 between 7 and 15 July 1993. Locations of the VW and VMPs are shown on Figure 1.6. Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Ms. Elizabeth Rosenberg of the ES office in Alameda, California.

Six boreholes were drilled at the site, and four were converted to either a VW or a VMP. Two boreholes were abandoned since contamination observed during drilling was not at sufficient levels for appropriate VW and VMP siting. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA measurements to determine appropriate VW and VMP screened intervals and total depths. Both a THVA and a PID were used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.3 summarizes pertinent borehole data.

### 1.2.2 Soil Profile

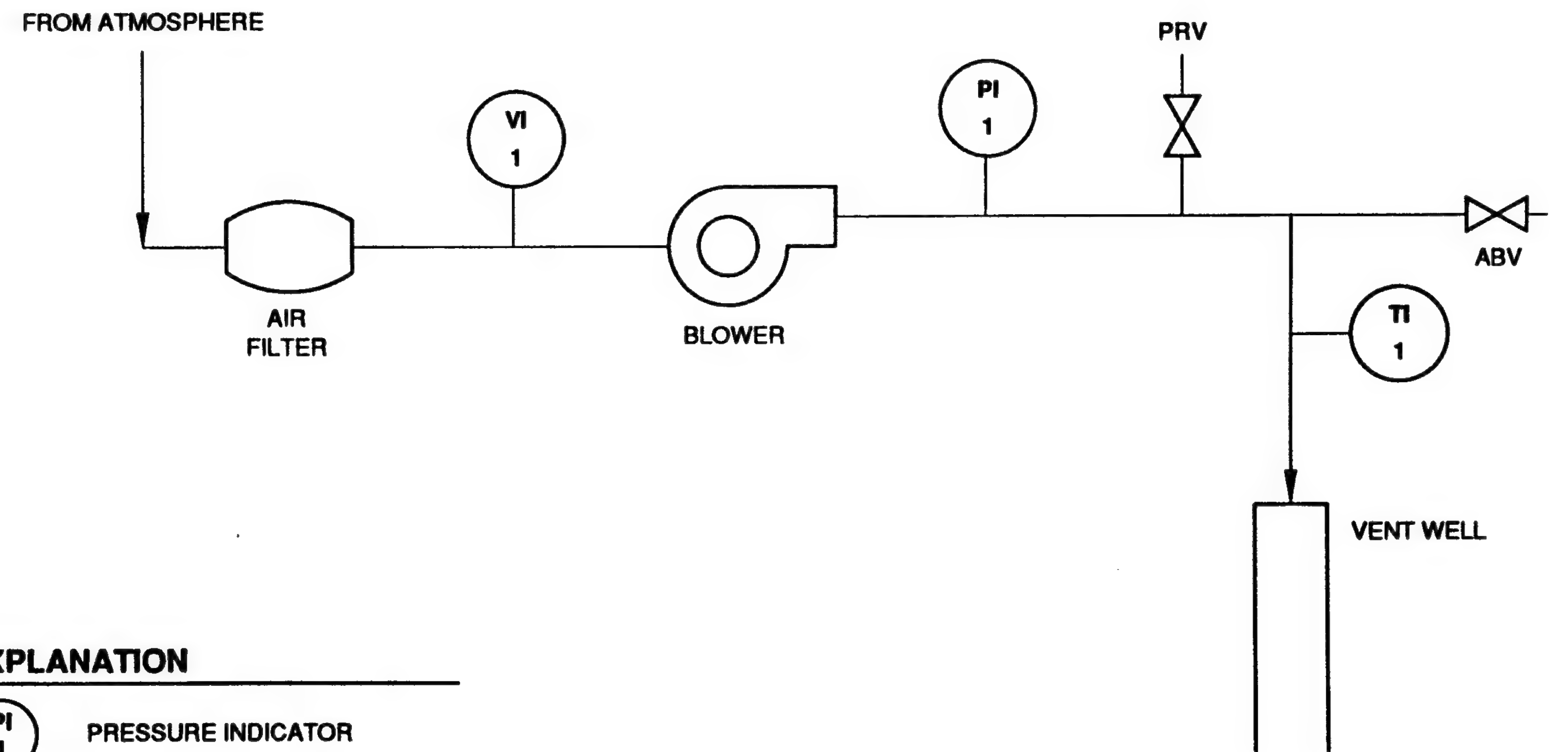
Figure 1.7 is a geologic cross-section of the pilot test site using data from the VW and three VMPs. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TPH-g concentrations from laboratory analysis of soil samples, and initial oxygen levels in soil gas. The soil boring logs are included in Appendix A.

Below the surface asphalt material, the observed soil profile in all of the boreholes except VMP-3 is heterogeneous brown fill material composed of gravel, sand, silt, and clay. The bottom of the fill material ranges from 11 feet bgs in VW-1 to 18 feet bgs in

FIGURE 1.5

# AS-BUILT BLOWER PROCESS FLOW AND INSTRUMENTATION DIAGRAM
## TF-2, TF-4, PRL T-46, AND DAVIS SITE

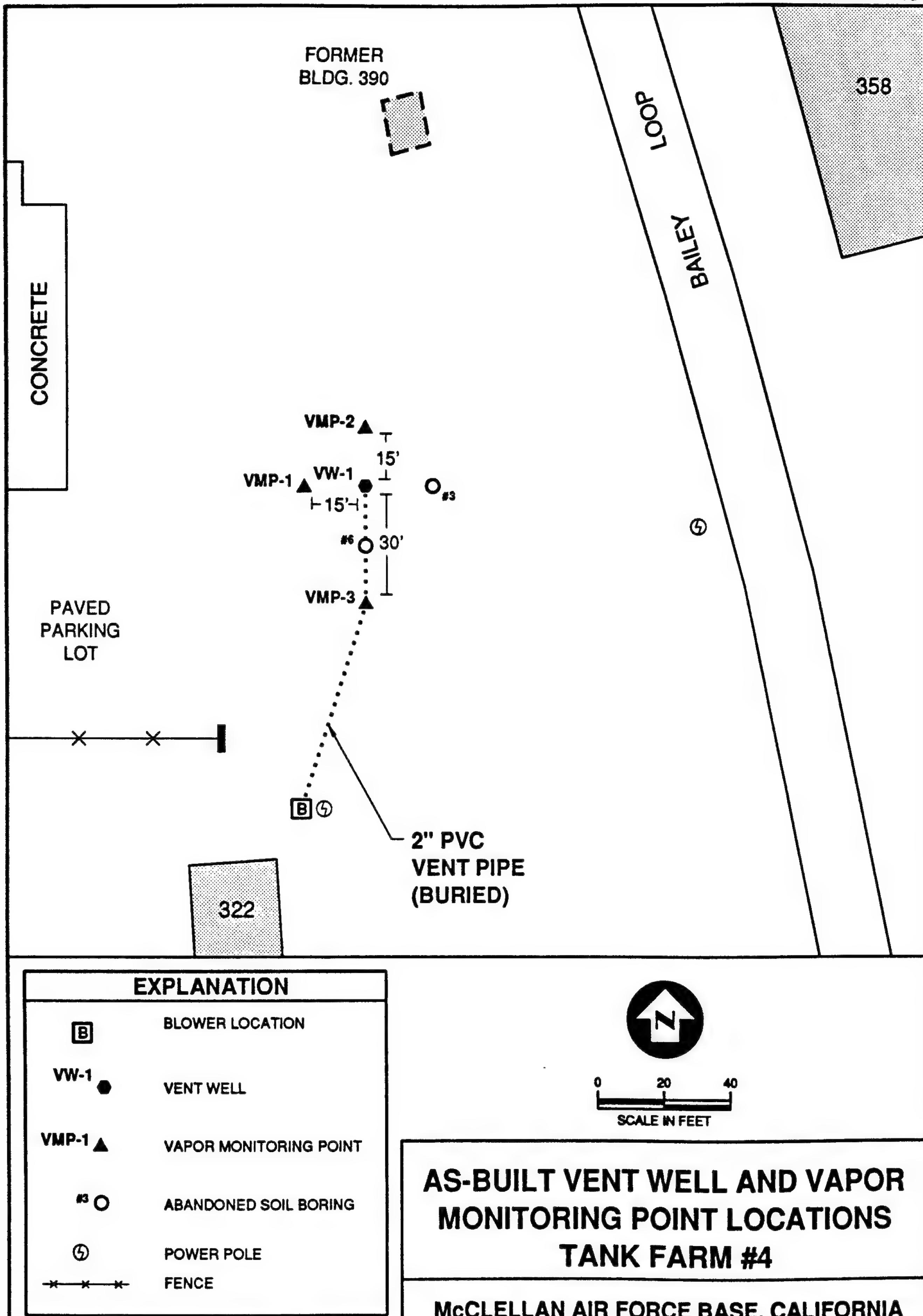
McCLELLAN AIR FORCE BASE, CALIFORNIA




**EXPLANATION**

| | |
|---|---|
| PI 1 | PRESSURE INDICATOR |
| TI 1 | TEMPERATURE INDICATOR |
| VI 1 | VACUUM INDICATOR |
| ABV | AIR BLEED VALVE |
| PRV | PRESSURE RELIEF VALVE |

FIGURE 1.6




SOURCE: MODIFIED FROM RADIAN (1990)

**AS-BUILT VENT WELL AND VAPOR MONITORING POINT LOCATIONS TANK FARM #4**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 4 C257-19.DWG 11/10/93

ENGINEERING-SCIENCE, INC.

# TABLE 1.3
# BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
## Tank Farm #4
## McClellan AFB, California

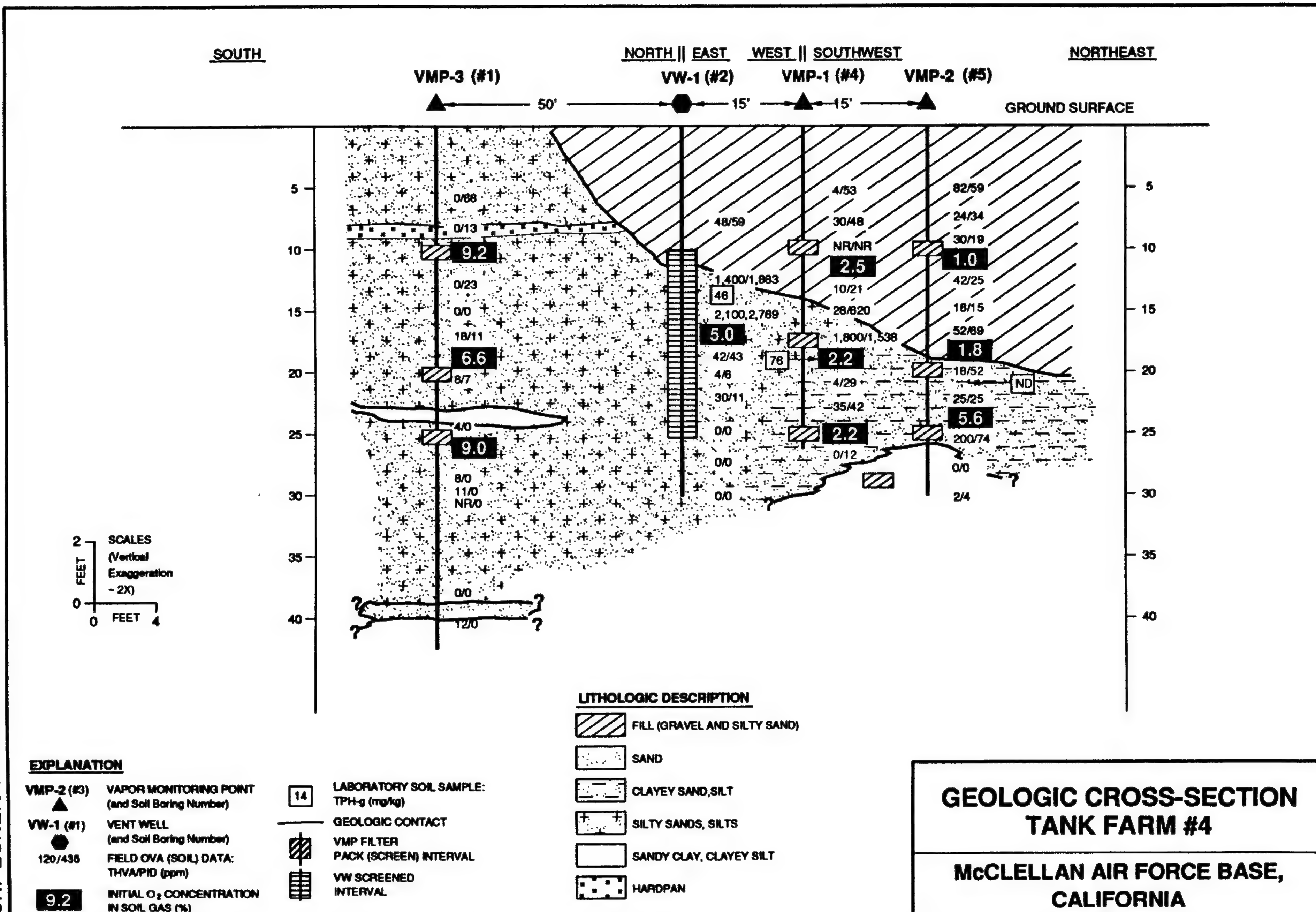
| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 40.5 | 3.5 – 6.0 | 0/67.7 | | 7/7/93 | 7/13/93 | VMP-3 |
| | | 6.0 – 8.5 | 0/13.2 | | | | |
| | | 11.0 – 13.5 | 0/23.4 | | | | |
| | | 13.5 – 16.0 | 0/0 | | | | |
| | | 16.0 – 18.5 | 18/10.7 | | | | |
| | | 18.5 – 21.0 | 8/6.5 | | | | |
| | | 21.0 – 23.5 | 4/0 | | | | |
| | | 23.5 – 26.0 | 8/0 | | | | |
| | | 26.0 – 28.5 | 14/0 | | | | |
| | | 28.5 – 32.0 | NR/0 | | | | |
| | | 32.0 – 38.0 | 0/0 | | | | |
| | | 38.0 – 40.5 | 12/0 | | | | |
| 2 | 31.5 | 5.0 – 7.5 | 48/59.0 | | 7/8/93 | 7/13/93 | VW-1 |
| | | 10.5 – 12.5 | 1400/1883 | TF4-BH2-12.5 | | | |
| | | 12.5 – 15.0 | 2100/2769 | | | | |
| | | 15.0 – 17.5 | 42/43.2 | | | | |
| | | 17.5 – 20.0 | 4/6.1 | | | | |
| | | 20.0 – 22.5 | 30/10.7 | | | | |
| | | 22.5 – 25.0 | 0/0 | | | | |
| | | 25.0 – 27.5 | 0/0 | | | | |
| | | 27.5 – 30.0 | 0/0 | | | | |
| 3 | 25.0 | 0 – 2.5 | 0/0 | | 7/8/93 | 7/15/93 | Abandoned |
| | | 2.5 – 5.0 | 30/42.3 | | | | |
| | | 5.0 – 7.5 | 0/0 | | | | |
| | | 7.5 – 10.0 | 0/0 | | | | |
| | | 10.5 – 12.5 | 0/8.1 | | | | |
| | | 12.5 – 15.0 | 0/0 | | | | |
| | | 15.0 – 17.5 | 16/5.0 | | | | |
| | | 17.5 – 20.0 | 24/6.1 | | | | |
| | | 20.0 – 22.5 | 7.3/16 | | | | |
| | | 22.5 – 25.0 | 7.5/8.0 | | | | |
| 4 | 25.5 | 0.0 – 5.0 | 4/53.1 | | 7/9/93 | 7/14/93 | VMP-1 |
| | | 5.0 – 7.5 | 30/48.4 | | | | |
| | | 10.5 – 12.5 | 10/20.8 | | | | |
| | | 12.5 – 15.0 | 28/620 | | | | |
| | | 15.0 – 17.5 | 1800/1538 | TF4-BH4-17.5 | | | |
| | | 17.5 – 20.0 | 4/29.5 | | | | |
| | | 20.0 – 22.5 | 35/42.0 | | | | |
| | | 22.5 – 25.0 | 0/11.7 | | | | |

## TABLE 1.3 (continued)
## BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
## Tank Farm #4
## McClellan AFB, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 5 | 30.0 | 2.5 – 5.0 | 82/59.3 | | 7/12/93 | 7/13/93 | VMP–2 |
| | | 5.0 – 7.5 | 24/34 | | | | |
| | | 7.5 – 10.0 | 30/19.1 | | | | |
| | | 10.5 – 12.5 | 42/24.7 | | | | |
| | | 12.5 – 15.0 | 16/15.1 | | | | |
| | | 15.0 – 17.5 | 52/69.0 | | | | |
| | | 17.5 – 20.0 | 18/52.0 | TF2–BH5–20 | | | |
| | | 20.0 – 22.5 | 25/25.7 | | | | |
| | | 22.5 – 25.0 | 200/74.0 | | | | |
| | | 25.0 – 27.5 | 0/0 | | | | |
| | | 27.5 – 30.0 | 2.0/4.5 | | | | |
| 6 | 22.5 | 2.5 – 5.0 | 48/200 | | 7/13/93 | 7/15/93 | Abandoned |
| | | 5.0 – 7.5 | 4/165 | | | | |
| | | 7.5 – 10.0 | 0/35.8 | | | | |
| | | 10.5 – 12.5 | 14/6.9 | | | | |
| | | 12.5 – 15.0 | 18/4.3 | | | | |
| | | 15.0 – 17.5 | 13/6.9 | | | | |
| | | 17.5 – 20.0 | 14/0 | | | | |
| | | 20.0 – 22.5 | 0/0 | | | | |

01/18/94
TF4TAB1.WK1

# FIGURE 1.7




**GEOLOGIC CROSS-SECTION TANK FARM #4**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 5 C258-41.DWG 02/09/94

ENGINEERING-SCIENCE, INC.

VMP-2. A mild fuel odor was noticeable in several samples of the fill material. A predominantly interbedded interval of tan-brown silty sands and silts with clayey sands and silts was found beneath the fill material. This interval exhibited areas of blue-green/grey discoloration and noticeable fuel odor in VW-1, VMP-1, and VMP-2. No fill material was encountered in VMP-3.

In VMP-3, the observed native soil profile down to 6 feet bgs is a red-brown silty, clayey sand. A clayey sand layer is found at approximately 6 to 8 feet bgs and is underlain by one half foot of highly indurated material (hardpan). Beneath the hardpan is the predominantly tan-brown silty sand and silt interval found in other borings. The soil profile shows an isolated sandy clay in VMP-3 from 23 to 24 feet bgs (and in VMP-2 from 26 feet bgs to the base of the borehole at 30 feet bgs). Beneath the sandy clay in VMP-3, sandy silt and silty sand are found to a depth of 39 feet bgs, where a loose, medium-grain sand is encountered from 39 to 40 feet bgs. Tan-brown clayey silt is found at the base of the VMP-3 borehole.

Groundwater was not encountered in any of the borings at the site.

### 1.2.3 Air Injection Vent Well

One air injection VW (VW-1) was installed in a location where soils exhibited a noticeable fuel odor following procedures described in the protocol document. VW-1 was installed approximately 150 feet southwest of the southwest corner of Building 358 (Figure 1.6). Table 1.4 presents construction data, and Figure 1.3 shows construction details for the VW.

VW-1 was constructed using 4-inch ID, Schedule 40 PVC casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with size 6-12 Lone Star sand (filter pack material) from 25 feet bgs to 1 foot above the top of the screen. A small amount of size 1-C Lone Star sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval.

To prevent preferential air movement near the surface during pilot testing, a 4-foot thick annular bentonite seal was emplaced on top of the filter pack. The annulus of the well was then filled with a bentonite/cement grout. The upper 2.5 feet of annular space was left vacant for ease of connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The upper 2 feet of well casing was completed with a 4-inch diameter Schedule 40 PVC tee and a 4-inch PVC cap. The tee was connected to the 2-inch diameter PVC pipe from the blower unit and fitted with a flow control valve to isolate the VW for sampling purposes. The surface completion of the VW consisted of a water-tight, traffic-proof, cast-iron well box (securable with hexbolts) emplaced within a 3-foot diameter concrete collar sloped away from the box for drainage.

VW-1 was connected to the blower unit by 2-inch diameter Schedule 40 PVC pipe buried in a trench. Surface asphalt was cut away and removed prior to trenching work. The trench, 30 feet long, 4 inches wide, and 1 foot deep, was excavated from near VMP-3 to VW-1, and PVC pipe was laid in the trench. Near VMP-3, the pipe was connected to a pre-existing buried PVC pipe. After securing the pipe, soil was returned

# TABLE 1.4
# VMP/VW CONSTRUCTION DATA
## Tank Farm #4
## McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VW-1 | 31.5 | 10.0 – 25.0 | – | 9.0 – 25.0 | 5.0 – 9.0 | 2.5 – 5.0 |
| | | | | | 25.0 – 31.5 | |
| VMP-1 | 25.5 | – | 10.0 | 9.5 – 10.5 | 3.0 – 9.5 | None |
| | | | 17.5 | 17.0 – 18.0 | 10.5 – 17.0 | |
| | | | 25.0 | 24.5 – 25.5 | 18.0 – 24.5 | |
| VMP-2 | 30.0 | – | 9.5 | 9.0 – 10.0 | 3.0 – 9.0 | None |
| | | | 20.0 | 19.5 – 20.5 | 10.0 – 19.5 | |
| | | | 24.5 | 24.0 – 25.0 | 20.5 – 24.0 | |
| | | | | | 25.0 – 30.0 | |
| VMP-3 | 40.5 | – | 10.0 | 9.5 – 10.5 | 3.0 – 9.5 | None |
| | | | 20.0 | 19.5 – 20.5 | 10.5 – 19.5 | |
| | | | 25.0 | 24.5 – 25.5 | 20.5 – 24.5 | |
| | | | | | 25.5 – 40.5 | |

01/18/94

TF4TAB2.WK1

to the trench and compacted. Asphalt was then replaced over the trenched area. The pre-existing, horizontal PVC pipe, which was elbowed below ground at the designated blower location, was connected directly to the portable blower unit for the initial pilot test and then to the fixed blower unit for the extended pilot test.

### 1.2.4 Vapor Monitoring Points

VMP-1 was installed 15 feet west of VW-1, VMP-2 was installed 15 feet north of VW-1, and VMP-3 was installed 30 feet south of VW-1 (Figure 1.6). The wells are near the location of former underground fuel storage tanks and fuel distribution system piping. Exact well placement was based on field OVA measurements and observations.

All VMPs were installed following procedures described in the protocol document. Table 1.4 shows construction data, and Figure 1.4 shows construction details for the VMPs. The three VMPs have nearly identical construction details, with the exception of VMP-1 which has one screened interval at a slightly shallower depth. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Three casing strings/screens were installed in each VMP borehole, with screen centers at depths of 10, 20, and 25 feet bgs (10, 17.5, and 25 feet bgs in VMP-1), to provide monitoring points at variable depths, soil types, and contamination levels.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and were centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-1, thermocouples were installed adjacent to the 10 and 25 foot screens to allow measurement of soil temperature. The surface of each VMP was completed with a flush-mount well box similar to the VW surface completion.

### 1.2.5 Blower Units

A portable 3.0-HP Roots™ positive displacement blower unit was used for the initial pilot test, powered by an on site 230V, single-phase, 30A line provided by the base. A fixed 1.0-HP Gast™ regenerative blower unit (model R4) was installed and began operation on 25 August 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power pole and blower are shown on Figure 1.6.

At the time of installation, the fixed blower unit was injecting approximately 25 scfm for the extended pilot test. Figure 1.5 shows the process flow and instrumentation diagram for this system. ES personnel provided an O&M data collection sheet and blower maintenance manual to base personnel. A sample copy of the data collection sheet and maintenance manual is provided in Appendix B.

### 1.2.6 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.

## 1.3 SA 6

### 1.3.1 Introduction

Installation of two VMPs was conducted at the SA 6 Site between 16 and 21 July 1993. Locations of both pre-existing and installed VWs and VMPs are shown on Figure 1.8. Borehole drilling services for newly-installed VMP-1 and VMP-2 were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Mr. Henry Pietropaoli of the ES office in Alameda, California.

Five boreholes were drilled at the site and two were converted to VMPs. Three boreholes were abandoned due to auger refusal or underground utilities. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA to determine appropriate VW and VMP screened intervals and total depths. Both a THVA and a PID were used to screen field samples. One soil sample was also collected for laboratory analysis. Table 1.5 summarizes pertinent borehole data.

### 1.3.2 Soil Profile

Figure 1.9 is a geologic cross-section of the pilot test site using data from the two pre-existing VWs (VW-18 and VW-19) and the two newly-installed VMPs (VMP-1 and VMP-2). The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TPH-g concentrations from laboratory analysis of soil samples collected during ES drilling operations, and initial oxygen levels in soil gas. The soil boring logs for boreholes drilled by ES are included in Appendix A.

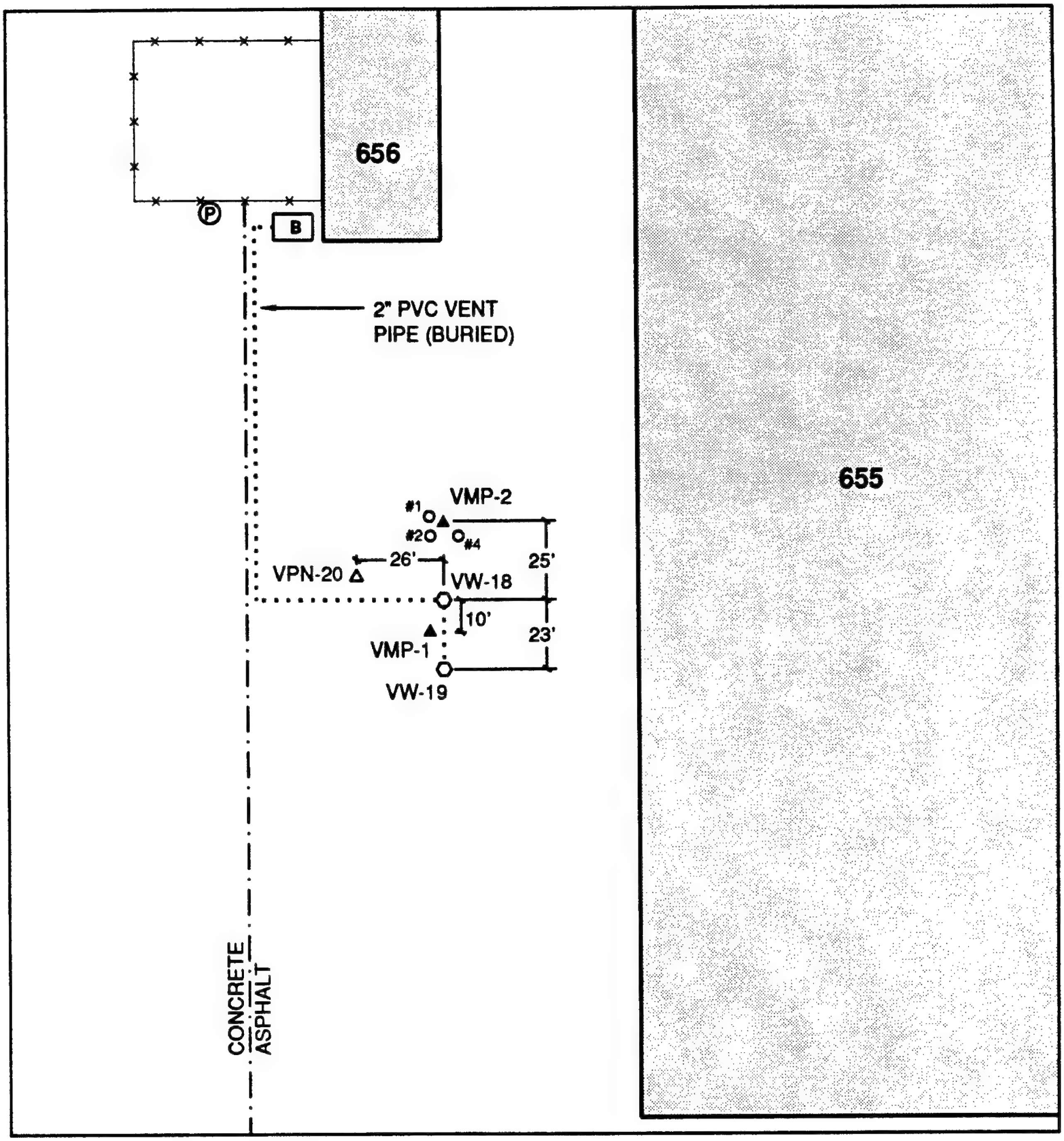
Below the surface asphalt material a silty, clay fill is found in VMP-1 and VMP-2. The base of the fill was encountered in VMP-1 at approximately 5 feet bgs and in VMP-2 at approximately 11 feet bgs; the base of the fill in pre-existing wells VPN-20 and VW-18 as shown in Figure 1.9 is only speculative. In all boreholes, the native soil material from ground surface to approximately 40 to 45 feet bgs (60 feet bgs in VW-19) consists of predominantly sands and silty sands with some interbedded silt lenses. Beneath this gross interval, the soil profile consists of silts and clays with minor interbedded sand lenses, although thicker sand intervals at 50 to 70 and 78 to 88 feet bgs were encountered at VW-18. In VMP-1 and VMP-2, the silts and sands are generally yellow-brown and green-brown. A layer of silty clay is found in VMP-1 and VMP-2 from approximately 25 to 35 feet bgs. Blue-green discoloration and noticeable fuel odors were reported in the sands and clays as deep as 35 feet and 45 feet bgs in VMP-1 and VMP-2, respectively.

Groundwater was not encountered in any of the borings at this site.

### 1.3.3 Air Injection Vent Wells

Two air injection VWs (VW-18 and VW-19) were previously installed at SA 6 by Radian Corporation in February 1993. VW-18 is located approximately 120 feet south of

FIGURE 1.8




**EXPLANATION**

656 BUILDING
CONCRETE/ASPHALT BORDER
POWER LINE
BLOWER LOCATION
VPN-20 PRE-EXISTING VAPOR MONITORING POINT (VAPOR PIEZOMETER NEST)
VW-18 PRE-EXISTING VENT WELL
VMP-1 VAPOR MONITORING POINT
#4 ABANDONED BOREHOLES
FENCE

0 25 50
SCALE IN FEET

**AS-BUILT VENT WELL AND VAPOR MONITORING POINT LOCATIONS SA 6**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

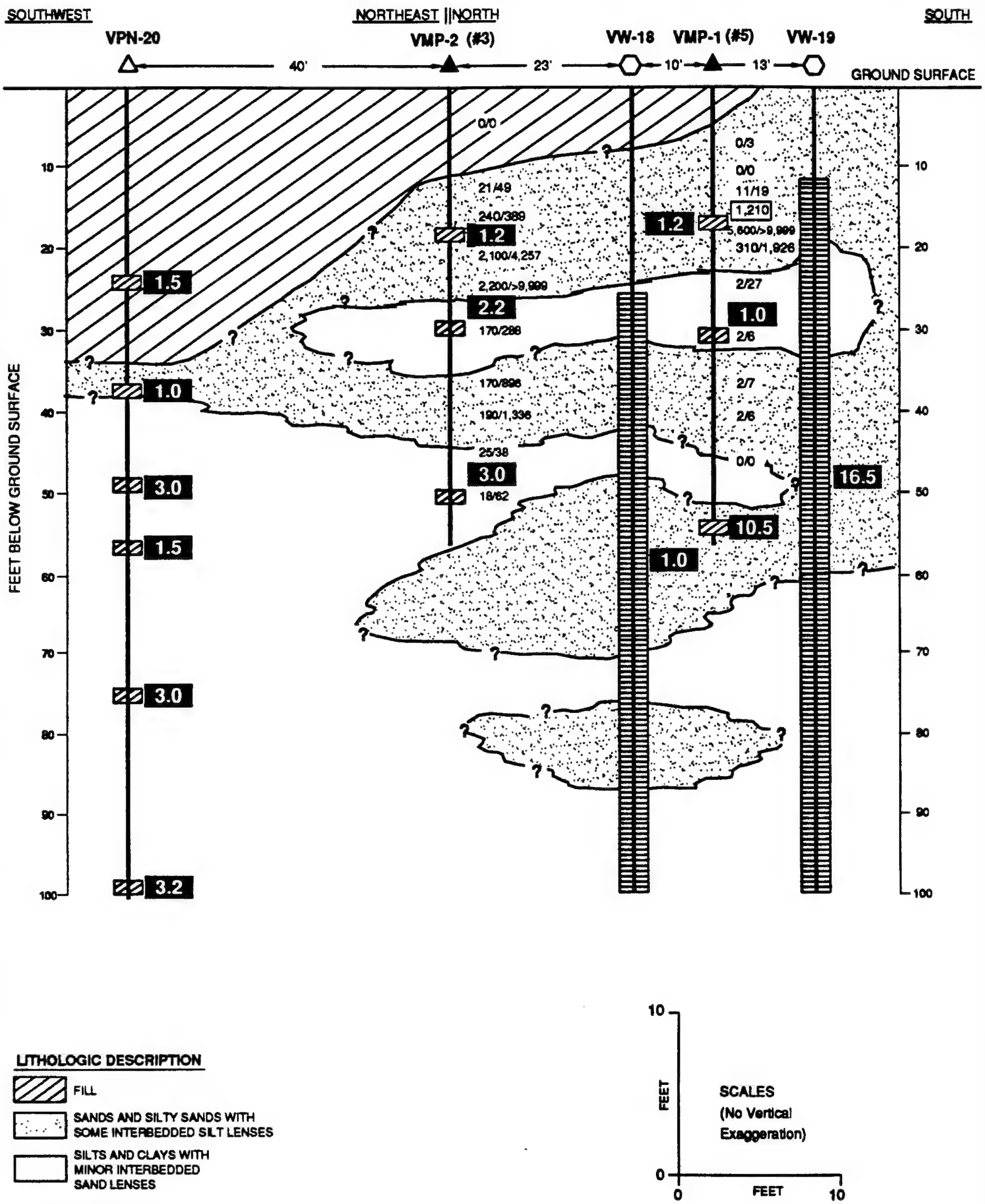
REV. 6 C257-05.DWG 01/12/94

ENGINEERING-SCIENCE, INC.

# TABLE 1.5
# BOREHOLE, SOIL SAMPLE, AND VMP SUMMARY DATA
# SA 6
# McClellan AFB, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 4.0 | not sampled | | | 7/16/93 | 7/21/93 | Abandoned |
| 2 | 6.0 | not sampled | | | 7/16/93 | 7/21/93 | Abandoned |
| 3 | 56.0 | 2.5 – 5.0 | 0/0 | | 7/16/93 | 7/21/93 | VMP-2 |
| | | 10.0 – 12.5 | 21/49 | | | | |
| | | 15.0 – 17.5 | 240/389 | | | | |
| | | 17.5 – 20.0 | 2100/4257 | | | | |
| | | 22.5 – 25.0 | 2200/>9999 | | | | |
| | | 27.5 – 30.0 | 170/288 | | | | |
| | | 32.5 – 35.0 | 170/896 | | | | |
| | | 37.5 – 40.0 | 190/1336 | | | | |
| | | 42.5 – 45.0 | 25/38 | | | | |
| | | 47.5 – 50.0 | 18/62 | | | | |
| 4 | 17.0 | not recorded | | | 7/19/93 | 7/21/93 | Abandoned |
| 5 | 56.0 | 2.5 – 5.0 | 0/3.1 | | 7/19/93 | 7/20/93 | VMP-1 |
| | | 7.5 – 10.0 | 0/0 | | | | |
| | | 12.5 – 15.0 | 11/19 | | | | |
| | | 15.0 – 17.5 | 5600/>9999 | SA6-VMP1-17.5 | | | |
| | | 17.5 – 20.0 | 310/1926 | | | | |
| | | 22.5 – 25.0 | 2/27 | | | | |
| | | 27.5 – 30.0 | 2/6.0 | | | | |
| | | 32.5 – 35.0 | 2/6.9 | | | | |
| | | 37.5 – 40.0 | 2/6.0 | | | | |
| | | 42.5 – 45.0 | 0/0 | | | | |

FIGURE 1.9




## LITHOLOGIC DESCRIPTION

- FILL
- SANDS AND SILTY SANDS WITH SOME INTERBEDDED SILT LENSES
- SILTS AND CLAYS WITH MINOR INTERBEDDED SAND LENSES

## EXPLANATION

| | |
|---|---|
| VMP-2 (#1) △ | PRE-EXISTING VAPOR MONITORING POINT (and Soil Boring Number) |
| VMP-2 (#1) ▲ | VAPOR MONITORING POINT (and Soil Boring Number) |
| VW-1 (#1) ⬡ | VENT WELL (and Soil Boring Number) |
| 120/435 | FIELD OVA (SOIL) DATA: THVA/PID (ppm) |
| 14 | LABORATORY SOIL SAMPLE: TPH-g (mg/kg) |
| — | GEOLOGIC CONTACT |
| | VMP FILTER PACK (SCREEN) INTERVAL |
| | VW SCREENED INTERVAL |
| 3.2 | INITIAL $O_2$ CONCENTRATION IN SOIL GAS (%) |

# GEOLOGIC CROSS-SECTION SA 6

## McCLELLAN AIR FORCE BASE CALIFORNIA

REV. 5 C264-02.DWG 02/09/94

ENGINEERING-SCIENCE, INC.

Building 656. VW-19 is located 23 feet south of VW-18 (Figure 1.8). VW-18 is screened from 25 to 100 feet bgs and VW-19 is screened from 15 to 100 feet bgs. Both wells are constructed of 4-inch diameter Schedule 40 PVC.

The previously existing surface well boxes installed by Radian were cut with an acetylene torch and removed; the surrounding concrete was jackhammered loose. The upper 2 feet of each well casing was subsequently completed with a 4-inch diameter Schedule 40 PVC tee and a 4-inch PVC cap. The tees were connected to 2-inch diameter PVC pipe from the blower unit, and each was fitted with a flow control valve to isolate the VW for sampling purposes. A one-foot length of PVC pipe was placed between each tee and each flow control valve to permit air flow measurement and flow balancing between the two VWs. The new surface completions of the VWs consisted of a 2 feet by 3 feet box (securable with hexbolts) emplaced within a concrete collar sloped away from the box for drainage. The large box for each VW was necessary to enclose the well casing, the one-foot length of PVC pipe, and the flow control valve.

The VWs were connected to the blower unit by 2-inch diameter Schedule 40 PVC pipe buried in a trench 4 inches wide, and 1 foot deep. Asphalt, from 6 to 8 inches in thickness, was cut away and removed prior to trenching work. After PVC pipe was laid in the trench and secured, sand was placed in the trench and compacted, and asphalt was replaced over the trenched area. The subsurface pipe runs northward from VW-19 to a tee connection with subsurface pipe from VW-18. The pipe then runs approximately 49 feet west to the edge of the concrete, approximately 120 feet north to the blower location, and then elbows below ground to vertical. The top of the vertical PVC pipe was cut to approximately two foot above ground surface. The above ground pipe was connected directly to the portable blower unit for the initial pilot test and to the fixed blower unit located adjacent to the well for the extended pilot test.

### 1.3.4 Vapor Monitoring Points

VMP-1 was installed 10 feet south and 1.5 feet west of VW-18, and VMP-2 was located 25 feet north of VW-18 (Figure 1.8). VMP-1 and VMP-2 were installed in areas of noticeable fuel odor and soil discoloration. VPN-20 (Vapor Piezometer Nest), located 5 feet north and 26 feet west of VW-18, was previously installed by Radian Corporation in February 1993. VPN-20 was formerly designated as VW-7.

VMP-1 and VMP-2 were installed following procedures described in the protocol document. Table 1.6 shows construction data, and Figure 1.4 shows construction details for these VMPs. VMP-1 and VMP-2 have similar construction details. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Three casing strings/screens were installed in both VMP-1 and VMP-2 to provide monitoring points at variable depths, soil types, and contamination levels. The center of the screened intervals for each VMP are located as follows: 17, 30, and 54 feet bgs for VMP-1; 19.5, 30, and 49 feet bgs for VMP-2.

VMP-1 and VMP-2 screened intervals were 6 inches in length at the bottom of each individual PVC casing string and were centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand.

# TABLE 1.6
# VMP CONSTRUCTION DATA
# SA 6
# McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VMP−1 | 56.0 | – | 17.0 | 16.5 – 17.5 | 3.0 – 16.5 | None |
| | | | 30.0 | 29.5 – 30.5 | 17.5 – 29.5 | |
| | | | 54.0 | 53.5 – 54.5 | 30.5 – 53.5 | |
| | | | | | 54.5 – 56.0 | |
| VMP−2 | 56.0 | – | 19.5 | 19.0 – 20.0 | 3.0 – 19.0 | None |
| | | | 30.0 | 29.5 – 30.5 | 20.0 – 29.5 | |
| | | | 49.0 | 48.5 – 49.5 | 30.5 – 48.5 | |
| | | | | | 49.5 – 56.0 | |

01/18/94

SA6TAB2.WK1

These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-1, thermocouples were installed adjacent to the 17 and 54 foot screens to allow measurement of soil temperature. The surface of VMP-1 and VMP-2 were completed with a flush-mount well box.

VPN-20 was previously constructed using 1-inch ID Schedule 80 PVC casing. Six individual casing strings/screens were installed in the borehole with screened intervals centered at depths of 24, 37, 49, 57, 75 and 99 feet bgs, labelled P6 through P1, respectively. Each screen was two feet in length.

### 1.3.5 Blower Units

A portable 3.0-HP Roots™ positive displacement blower unit was used for the initial pilot test, powered by an on site 230V, single-phase, 30A line provided by the base. A fixed 2.0-HP Gast™ regenerative blower unit (model R5) was installed and began operation on 3 September 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power line and blower are shown on Figure 1.8.

At the time of installation, the fixed blower unit was injecting a total of 110 scfm into the two VWs for the extended pilot test. The flow is balanced so that approximately 45% of the total air flow is injecting into VW-18, which has the shorter screen length, and 55% of the total air flow is injecting into VW-19, which has the longer screen length. Figure 1.10 shows the process flow and instrumentation diagram for this system. ES personnel provided an O&M data collection sheet and blower maintenance manual to base personnel. A sample copy of the data collection sheet and maintenance manual is provided in Appendix B.

### 1.3.6 Exceptions to Protocol Document Procedures

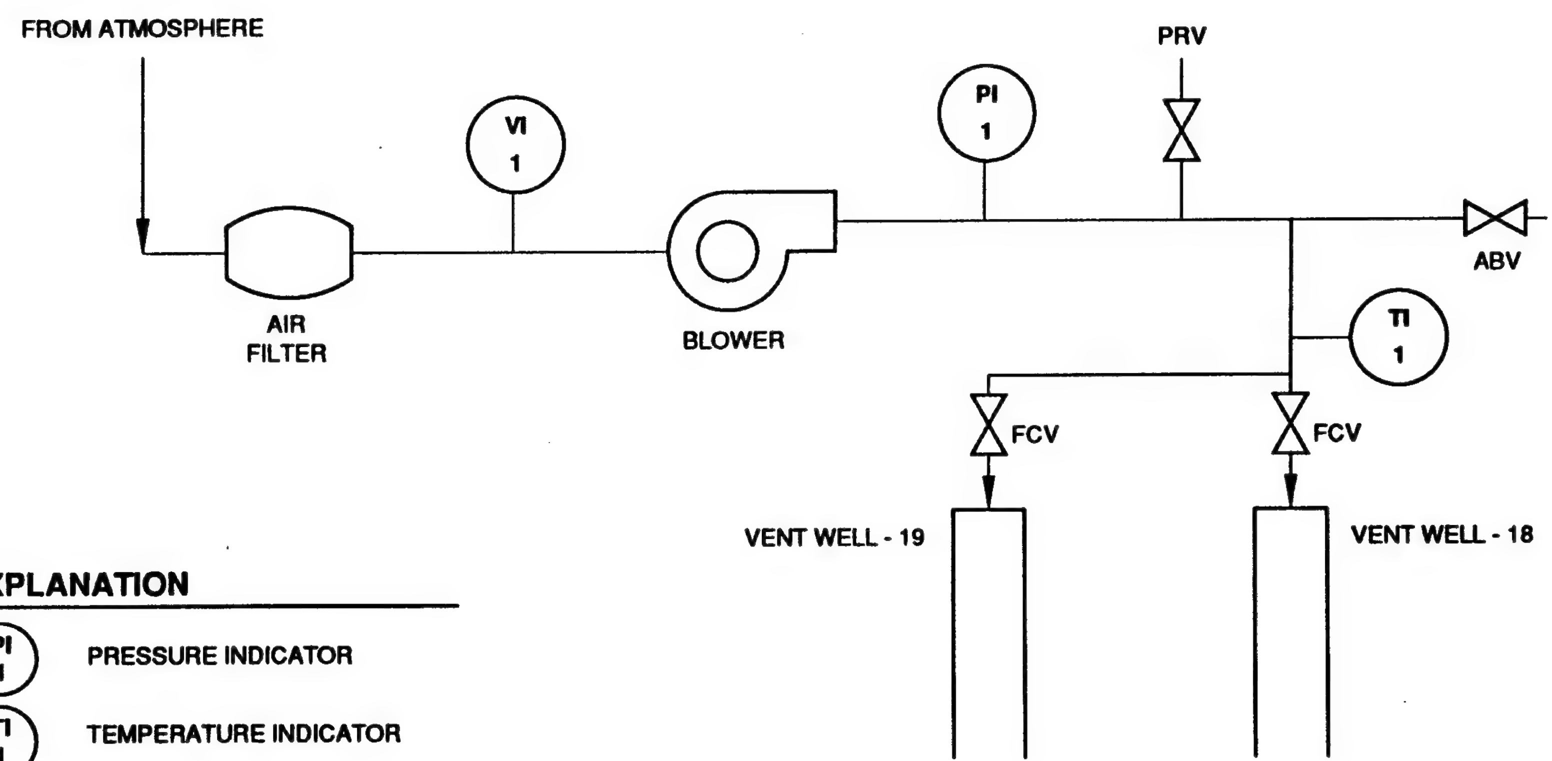
Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.
- Two wells previously installed by Radian Corporation were utilized as VWs and connected together with subsurface piping for the purpose of extended pilot testing design and implementation.

## 1.4 PRL T-46

### 1.4.1 Introduction

Installation of one VW and three VMPs was conducted at PRL T-46 between 12 and 16 July 1993. Locations of the VW and VMPs are shown on Figure 1.11. Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Mr. Henry Pietropaoli of the ES office in Alameda, California.




## EXPLANATION

| | |
|---|---|
| PI 1 | PRESSURE INDICATOR |
| TI 1 | TEMPERATURE INDICATOR |
| VI 1 | VACUUM INDICATOR |
| ABV | AIR BLEED VALVE |
| PRV | PRESSURE RELIEF VALVE |
| FCV | FLOW CONTROL VLAVE |

**AS-BUILT BLOWER PROCESS FLOW AND INSTRUMENTATION DIAGRAM SA 6**

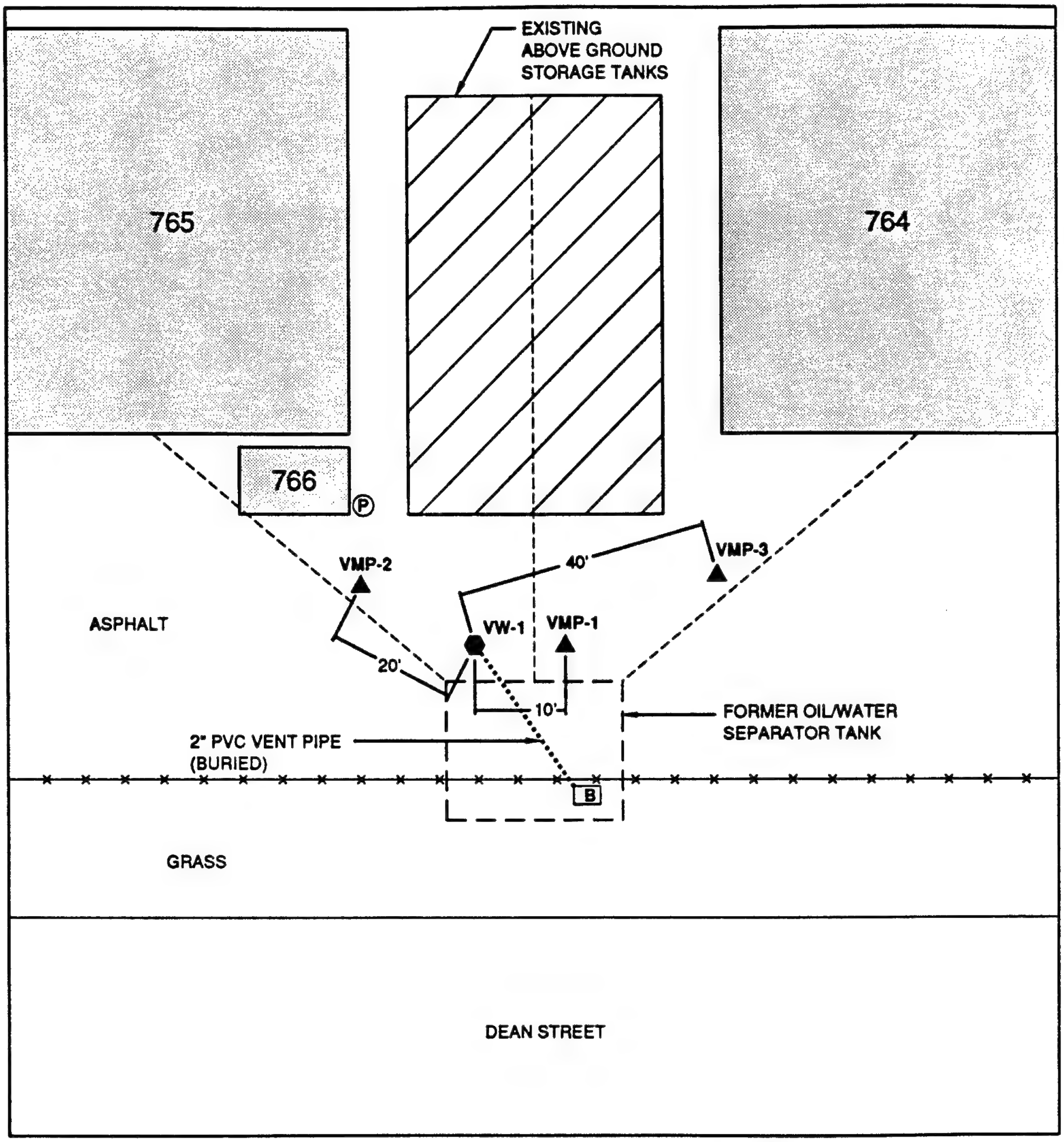
**McCLELLAN AIR FORCE BASE, CALIFORNIA**

FIGURE 1.10

REV. 2 C257-25.DWG 11/10/93

ENGINEERING-SCIENCE, INC.

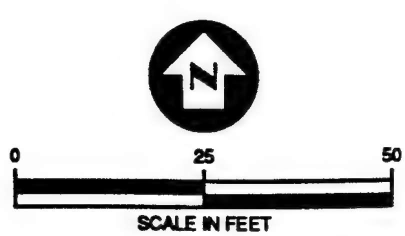
FIGURE 1.11




**EXPLANATION**

- B — BLOWER LOCATION
- P — POWER LINE
- VMP-3 — VAPOR MONITORING POINT
- VW-1 — VENT WELL
- —X—X— FENCE
- ------ DRAIN LINE

SOURCE: MODIFIED FROM RADIAN (1993).




**AS-BUILT VENT WELL AND VAPOR MONITORING POINT LOCATIONS PRL T-46**

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 4 C257-06.DWG 11/10/93

ENGINEERING-SCIENCE, INC.

# TABLE 1.7
# BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
# PRL T-46
# McClellan AFB, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 55 | 2.5 – 5.0 | 120/540 | | 7/12/93 | 7/15/93 | VW-1 |
| | | 7.5 – 10.0 | 690/1248 | | | | |
| | | 12.5 – 15.0 | 1100/3228 | | | | |
| | | 15.0 – 17.5 | 1300/3960 | PRL-46-VW1-17.5 | | | |
| | | 17.5 – 20.0 | 800/2492 | | | | |
| | | 22.5 – 25.0 | 900/3900 | | | | |
| | | 27.5 – 30.0 | 220/411 | | | | |
| | | 32.5 – 35.0 | 243/39 | | | | |
| | | 37.5 – 40.0 | 2/46 | | | | |
| | | 42.5 – 45.0 | 62/341 | | | | |
| | | 47.5 – 50.0 | 46/512 | | | | |
| | | 52.5 – 55.0 | 160/430 | | | | |
| 2 | 30 | 2.5 – 5.0 | 0/249 | | 7/13/93 | 7/15/93 | VMP-2 |
| | | 7.5 – 10.0 | 22/151 | | | | |
| | | 10.0 – 12.5 | 86/238 | PRL-46-VMP2-12.5 | | | |
| | | 12.5 – 15.0 | 8/46 | | | | |
| | | 22.5 – 25.0 | 6/34 | | | | |
| | | 27.5 – 30.0 | 2/11 | | | | |
| 3 | 45 | 2.5 – 5.0 | 800/3327 | | 7/13/93 | 7/15/93 | VMP-1 |
| | | 7.5 – 10.0 | 910/6423 | PRL-46-VMP1-10 | | | |
| | | 12.5 – 15.0 | 390/1606 | | | | |
| | | 17.5 – 20.0 | 98/612 | | | | |
| | | 22.5 – 25.0 | 18/167 | | | | |
| | | 32.5 – 35.0 | 0/0 | | | | |
| | | 37.5 – 40.0 | 0/40 | | | | |
| | | 42.5 – 45.0 | 0/0 | | | | |
| 4 | 30.5 | 2.5 – 5.0 | 12/36 | | 7/14/93 | 7/15/93 | VMP-3 |
| | | 7.5 – 10.0 | 3/18.2 | | | | |
| | | 12.5 – 15.0 | 0/0 | | | | |
| | | 17.5 – 20.0 | 0/0 | | | | |
| | | 22.5 – 25.0 | 0/0 | | | | |
| | | 27.5 – 30.0 | 0/0 | | | | |

01/18/94
T46TAB1.WK1

Four boreholes were drilled at the site and all were converted to either a VW or a VMP. No boreholes were abandoned since contamination observed during drilling was at sufficient levels for VW and VMP siting. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA to determine appropriate VW and VMP screened intervals and total depths. Both a THVA and a PID were used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.7 summarizes pertinent borehole data.

### 1.4.2 Soil Profile

Figure 1.12 is a geologic cross-section of the pilot test site using data from the VW and three VMPs. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TRPH concentrations from laboratory analysis of soil samples, and initial oxygen levels in soil gas. The soil boring logs are included in Appendix A.

Below the 6-inch layer of asphalt, the observed soil profile to a depth of 3 to 5 feet bgs is a brown to red-brown silty clay material. This material is interpreted to be base fill material for the asphalt surface layer. Beneath the fill, from 5 feet bgs to 25 feet bgs, is a zone of interbedded to interfingered silty clay to clay and clayey sand to silt. This zone appears as interbedded layers at the west end of the site and grades to interfingered layers at the east end of the site. Also this zone has a variable amount of lateral connectivity.

The soil profile for VMP-2 (the west end of site) presents a discolored blue-green silty clay layer from 5 feet bgs to 15 feet bgs, then a clayey silt to fine sand layer to 25 feet bgs. The basal 5 feet of the profile exhibits a light brown to yellow-brown silty clay.

Beneath the fill in VMP-3 (the east end of the site) the discolored blue-green silty clay is interfingered with clayey silt/sand from 6 feet bgs to approximately 23 feet bgs. Below this depth to 30 feet bgs is the same light brown to yellow-brown silty clay as observed in the lower 5 feet of VMP-2.

Soil profiles from VW-1 and VMP-1 reveal the light-brown to yellow-brown silty clay, appearing at 25 feet bgs, is underlain by a clayey sand to fine sand from 35 feet to 45 feet bgs. A silty clay to clay begins at 45 feet bgs and continues to the base of both VW-1 and VMP-1.

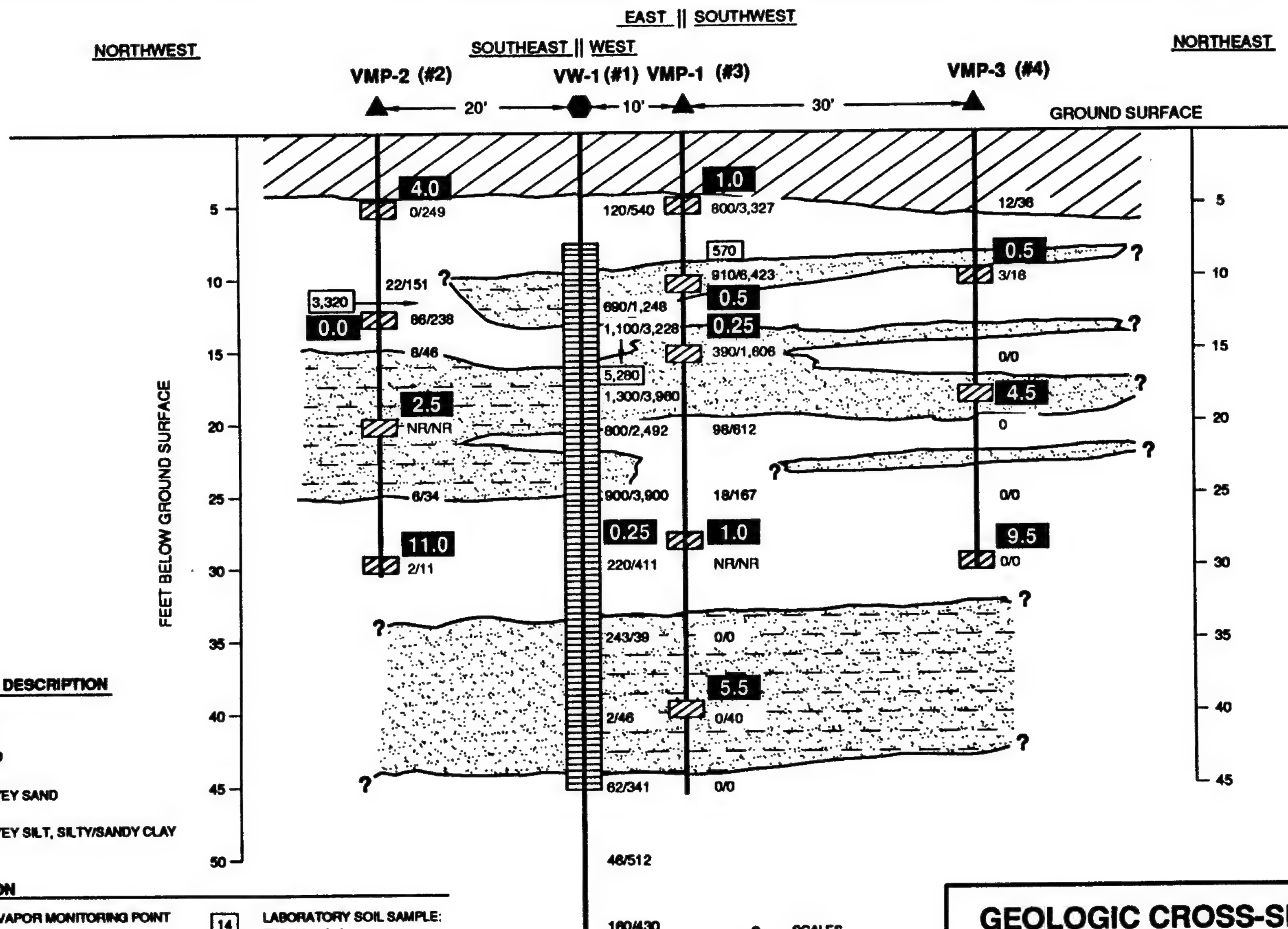
Contamination was observed in all boreholes in the form of fuel odors and blue-green discoloration at depths ranging from as shallow as 4 feet bgs in VW-1, VMP-1, and VMP-3 to as deep as 45 feet bgs in VW-1.

Groundwater was not encountered in any of the borings at the site.

### 1.4.3 Air Injection Vent Well

One air injection VW (VW-1) was installed in a location where soils exhibited a noticeable fuel odor following procedures described in the protocol document. VW-1 was installed approximately 5 feet north of the former oil/water separator tank and 30 feet southeast of Building 766 (Figure 1.11). Table 1.8 presents construction data, and Figure 1.3 shows construction details for the VW.

FIGURE 1.12




**LITHOLOGIC DESCRIPTION**

- FILL
- SAND
- CLAYEY SAND
- CLAYEY SILT, SILTY/SANDY CLAY

**EXPLANATION**

- VMP-2 (#3) — VAPOR MONITORING POINT (and Soil Boring Number)
- VW-1 (#1) — VENT WELL (and Soil Boring Number)
- 120/435 — FIELD OVA (SOIL) DATA: THVA/PID (ppm)
- 4.0 — INITIAL $O_2$ CONCENTRATION IN SOIL GAS (%)
- 14 — LABORATORY SOIL SAMPLE: TRPH (mg/kg)
- GEOLOGIC CONTACT
- VMP FILTER PACK (SCREEN) INTERVAL
- VW SCREENED INTERVAL

SCALES (Vertical Exaggeration ~ 2X)

FEET 0 – 2 (vertical); FEET 0 – 4 (horizontal)

# GEOLOGIC CROSS-SECTION PRL T-46

## McCLELLAN AIR FORCE BASE CALIFORNIA

REV. 5 C264-01.DWG 02/09/94

ENGINEERING-SCIENCE, INC.

# TABLE 1.8
# VMP/VW CONSTRUCTION DATA
# PRL T-46
# McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VW-1 | 50 | 8.0 – 45.0 | – | 7.0 – 45.0 | 4.0 – 7.0 | 2.0 – 4.0 |
| VMP-1 | 45 | – | 5.0 | 4.5 – 5.5 | 3.0 – 4.5 | None |
| | | | 10.0 | 9.5 – 10.5 | 5.5 – 9.5 | |
| | | | 15.0 | 14.5 – 15.5 | 10.5 – 14.5 | |
| | | | 28.0 | 27.5 – 28.5 | 15.5 – 27.5 | |
| | | | 40.0 | 39.5 – 40.5 | 28.5 – 39.5 | |
| | | | | | 40.5 – 45.0 | |
| VMP-2 | 30 | – | 5.0 | 4.5 – 5.5 | 3.0 – 4.5 | None |
| | | | 12.5 | 12.0 – 13.0 | 5.5 – 12.0 | |
| | | | 19.5 | 19.0 – 20.0 | 13.0 – 19.0 | |
| | | | 29.5 | 29.0 – 30.0 | 20.0 – 29.0 | |
| VMP-3 | 30.5 | – | 10.0 | 9.5 – 10.5 | 3.0 – 9.5 | None |
| | | | 18.0 | 17.5 – 18.5 | 10.5 – 17.5 | |
| | | | 30.0 | 29.5 – 30.5 | 18.5 – 29.5 | |

11/05/93

T46TAB2.WK1

VW-1 was constructed using 4-inch ID, Schedule 40 PVC casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with size 6-12 Lone Star sand (filter pack material) from 45 feet bgs to 1 foot above the top of the screen. A small amount of size 1-C Lone Star sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval.

To prevent preferential air movement near the surface during pilot testing, a 3-foot thick annular bentonite seal was emplaced on top of the filter pack. The annulus of the well was then filled with a bentonite/cement grout to approximately 2 feet bgs. The upper 2.0 feet of annular space was left vacant for ease of connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The upper 2 feet of well casing was completed with a 4-inch diameter Schedule 40 PVC tee and a 4-inch PVC cap. The tee was connected to the 2-inch diameter PVC pipe from the blower unit and fitted with a flow control valve to isolate the VW for sampling purposes. The surface completion of the VW consisted of a water-tight, traffic-proof, cast-iron well box (securable with hexbolts) emplaced within a 3-foot diameter concrete collar sloped away from the box for drainage.

VW-1 was connected to the blower unit by 2-inch diameter Schedule 40 PVC pipe buried in a trench. Surface asphalt was cut away and removed prior to trenching work. The trench, approximately 30 feet long, 4 inches wide, and 1 foot deep, was excavated from the blower location to VW-1, and PVC pipe was laid in the trench. After securing the pipe, soil was returned to the trench and compacted. Asphalt was then replaced over the trenched area. The horizontal pipe was elbowed below ground at the designated blower location and the top of the vertical PVC pipe was cut to approximately two feet above ground surface. The above ground PVC pipe was connected directly to the portable blower unit for the initial pilot test and then to the fixed blower unit for the extended pilot test.

### 1.4.4 Vapor Monitoring Points

VMP-1 was installed 10 feet due east of VW-1, parallel to the south fence bordering the property. VMP-2 and VMP-3 were installed 20 feet northwest and 40 feet northeast of VW-1, respectively, near the former drain lines (Figure 1.11).

All VMPs were installed following procedures described in the protocol document. Table 1.8 presents construction data, and Figure 1.4 shows construction details for the VMPs. Each VMP has a different number of screened intervals with VMP-1 containing 5 intervals, VMP-2 containing 4 intervals, and VMP-3 containing 3 intervals. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Three of the casing strings/screens in each VMP borehole were installed at approximately the same depths; the additional screens were installed to provide better characterization of the lithology at the site as well as to provide monitoring points at variable depths and contamination levels. The center of the screened intervals for each VMP are located as follows: 5, 10, 15, 28 and 40 feet bgs for VMP-1; 5, 12.5, 19.5 and 29.5 feet bgs for VMP-2; and 10, 18 and 30 feet bgs for VMP-3.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and was centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-1, two thermocouples were installed adjacent to screens at depths of 5 and 40 feet bgs to allow measurement of soil temperature. The surface of each VMP was completed with a flush-mount well box similar to the VW surface completion.

### 1.4.5 Blower Units

A portable 3.0-HP Roots™ positive displacement blower unit was used for the initial pilot test, powered by an on-site 230V, single-phase, 30A line provided by the base. A fixed 1.0-HP Gast™ regenerative blower unit (model R4) was installed and began operation on 27 August 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power line and blower are shown on Figure 1.11.

At the time of installation, the fixed blower unit was injecting approximately 68 scfm for the extended pilot test. Figure 1.5 shows the process flow and instrumentation diagram for this system. ES personnel provided an O&M data collection sheet and blower maintenance manual to base personnel. A sample copy of the data collection sheet and maintenance manual is provided in Appendix B.

### 1.4.6 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

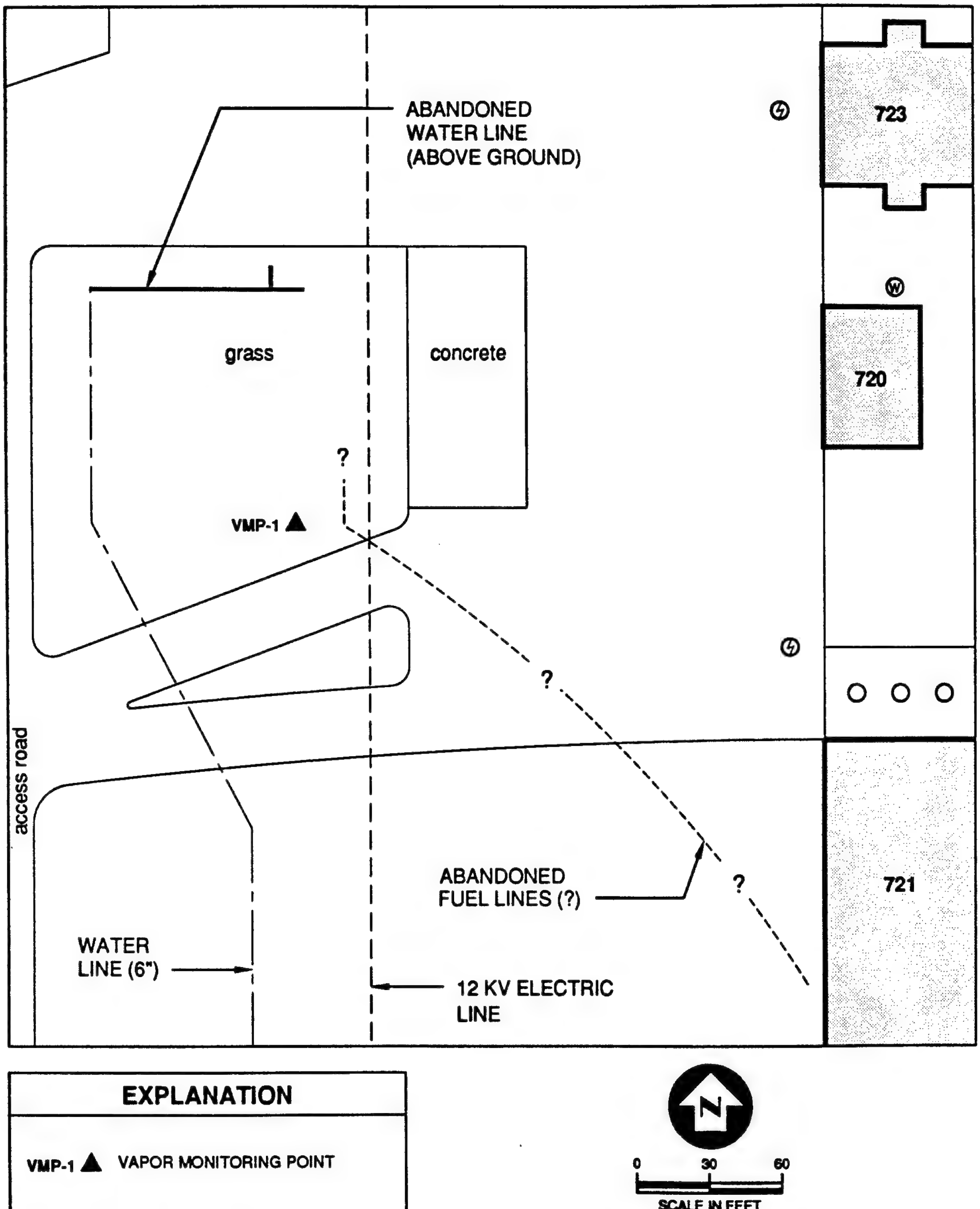
- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.

## 1.5 Building 720

### 1.5.1 Introduction

Installation of one VMP (VMP-1) was conducted at Building 720 on 14 and 15 July 1993. Location of the VMP is shown on Figure 1.13. Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Ms. Elizabeth Rosenberg and Mr. Henry Pietropaoli of the ES office in Alameda, California. Previously proposed boreholes were not drilled due to insufficiently depleted oxygen levels and visual observations of high levels of moisture in the soils. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA to determine appropriate VMP screened intervals and total depths. Due to equipment problems, only a PID was used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.9 summarizes pertinent borehole data.

FIGURE 1.13




**EXPLANATION**

| | |
|---|---|
| VMP-1 ▲ | VAPOR MONITORING POINT |
| ⊘ | UTILITY POLE |
| Ⓦ | WATER SUPPLY |
| ▭ | BUILDING |
| ○ | ABOVE GROUND STORAGE TANKS |

SOURCE: McCLELLAN AFB, MODIFIED FROM RADIAN (1991)

# AS-BUILT VAPOR MONITORING POINT LOCATION BUILDING 720

**McCLELLAN AIR FORCE BASE, CALIFORNIA**

REV. 4 C257-07.DWG 11/10/93

ENGINEERING-SCIENCE, INC.

# TABLE 1.9
# BOREHOLE, SOIL SAMPLE, AND VMP SUMMARY DATA
# Building 720
# McClellan AFB, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 21.0 | 0.0 – 3.0 | NR/297 | | 7/14/93 | 7/15/93 | VMP-1 |
| | | 3.0 – 6.0 | NR/726 | 720-BH1-6 | | | |
| | | 6.0 – 8.5 | NR/0 | | | | |
| | | 8.5 – 11.0 | NR/309 | | | | |
| | | 11.0 – 13.5 | NR/0 | | | | |
| | | 13.5 – 16.0 | NR/0 | | | | |
| | | 16.0 – 18.5 | NR/0 | | | | |
| | | 18.5 – 21.0 | NR/0 | | | | |

11/05/93
720TAB1.WK1

### 1.5.2 Soil Profile

The boring for VMP-1 was advanced to a total depth of 20 feet bgs. The soils from near the surface to 7.5 feet bgs were silts and sands with a noticeable petroleum odor. The interval from 5 to 7.5 feet bgs was a very moist sand and exhibited the highest soil headspace vapor reading. A layer of hardpan was found from 7.5 to 8.5 feet bgs. Silty sand was encountered below the hardpan to the base of the boring at 20 feet. Only the upper one foot of this silty sand, between 8.5 and 9.5 feet bgs, had any evidence of fuel contamination. The soil boring log for VMP-1 is included in Appendix A.

Groundwater was not encountered during drilling operations at the site.

### 1.5.3 Air Injection Vent Well

No VW was installed because unsuitable conditions for bioventing were found at the site. These conditions are discussed in detail in Section 2.5.

### 1.5.4 Vapor Monitoring Points

VMP-1 was installed approximately 220 feet west and 35 feet south of Building 720 (Figure 1.13) following procedures described in the protocol document. Table 1.10 presents construction data, and Figure 1.4 shows construction details for the VMP. VMP-1 was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Two casing strings/screens were installed in VMP-1 with screen centers at 6 feet bgs and 9 feet bgs.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and was centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. No thermocouples were installed. The surface of the VMP was completed with a flush-mount well box similar to the VMP surface completion at other sites.

### 1.5.5 Blower Units

No blower unit was installed at the site.

### 1.5.6 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- A VW, additional VMPs, and a blower unit were not installed because unsuitable conditions for bioventing were found at the site.
- Lone Star 6-12 sand was used for filter pack material in the VMP instead of 6-9 silica sand.
- Due to equipment problems, only a PID was used for OVA of soil samples in the field.

# TABLE 1.10
# VMP CONSTRUCTION DATA
# Building 720
# McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VMP-1 | 21.0 | – | 6.0 | 5.5 – 6.5 | 2.5 – 5.5 | None |
| | | | 9.0 | 8.5 – 9.5 | 6.5 – 8.5 | |
| | | | | | 9.5 – 21.0 | |

11/05/93

720TAB2.WK1

## 1.6 Base Fire Department (Background Well)

### 1.6.1 Introduction

Installation of one background VMP (VMP-1) was conducted at the Base Fire Department on 15 and 16 July 1993. Figure 1.14 shows the site location. Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Ms. Elizabeth Rosenberg of the Engineering-Science, Inc., office in Alameda, California.

One borehole was drilled at the site and was converted to the background VMP in order to measure background levels of oxygen and carbon dioxide that will be representative of the soils and depths encountered at the McClellan AFB bioventing sites. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA to determine appropriate VMP screened intervals and total depths. Both a THVA and a PID were used to screen field samples. One soil sample was also collected for laboratory analysis. Table 1.11 summarizes pertinent borehole data.

### 1.6.2 Soil Profile

The soil boring log for the borehole converted to the background VMP is included in Appendix A.

The boring was advanced to a total depth of 40 feet bgs. The soils from the surface to 4 feet bgs were very strongly indurated sands. The interval from 4 to 6 feet bgs was a strongly indurated sandy silt which graded to a hard silty clay below 6 feet bgs. This silty clay continued to approximately 11 feet bgs where a loose, medium to fine sand to silty sand layer was encountered which extended to 15 feet bgs. From 15 feet bgs to 21 feet bgs was a tan, medium to fine sand, which became interfingered with a silty sandy clay to approximately 26 feet bgs. The soil profile from 26 to 31 feet bgs exhibited a predominantly clayey silt grading to a medium to fine sand. The bottom 9 feet of VMP-1 (31 to 40 feet bgs) exhibited a sand to silt layer with minor proportions of clay.

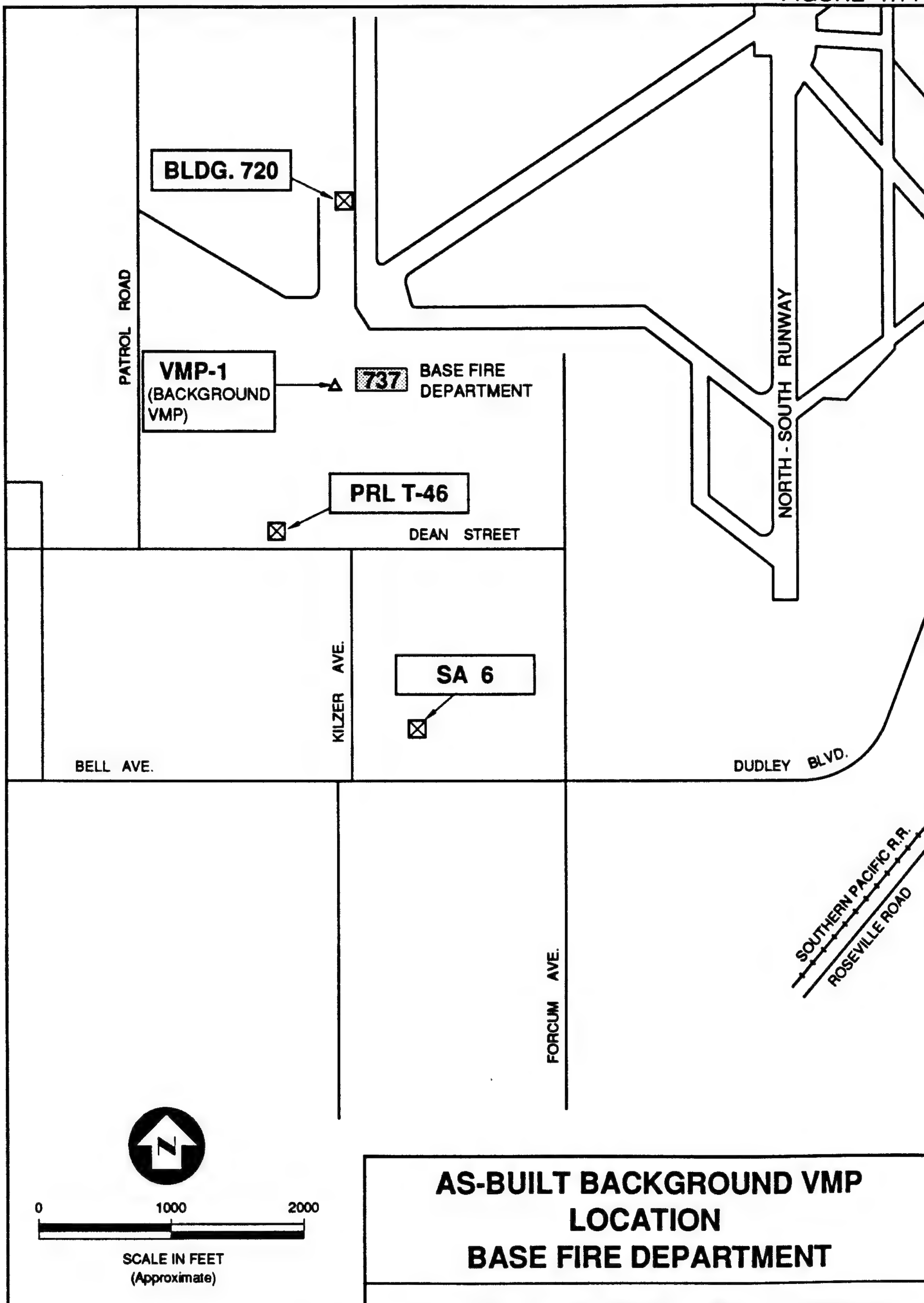
No contamination was observed in the physical features of the soil or determined based on the OVA readings. No groundwater was encountered during drilling operations at the site.

### 1.6.3 Vapor Monitoring Point

VMP-1 was installed approximately two feet off of the southwest edge of the asphalt area adjacent to the Base Fire Department and following procedures described in the protocol document. Table 1.12 presents construction data, and Figure 1.4 shows construction details for the VMP. VMP-1 was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Four casing strings/screens were installed in VMP-1 with screen centers at 8, 18, 28 and 39.5 feet bgs.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string, and was centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was

FIGURE 1.14




SOURCE: Modified from McClellan AFB

# AS-BUILT BACKGROUND VMP LOCATION
# BASE FIRE DEPARTMENT

## McCLELLAN AIR FORCE BASE, CALIFORNIA

REV. 4 C257-21.DWG 01/12/94

ENGINEERING-SCIENCE, INC.

# TABLE 1.11
# BOREHOLE, SOIL SAMPLE, AND VMP SUMMARY DATA
## Base Fire Department
## McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE |
|---|---|---|---|---|---|---|
| VMP-1 | 40.0 | 3.0 - 4.0 | 0/0 | | 7/15/93 | 7/16/93 |
| | | 5.0 - 6.0 | 0/0 | | | |
| | | 6.0 - 8.5 | 0/0 | | | |
| | | 11.0 - 13.5 | 0/0 | | | |
| | | 16.0 - 18.5 | 0/0 | | | |
| | | 21.0 - 23.5 | 0/0 | | | |
| | | 26.0 - 28.5 | 0/0 | FD-VMP1-28 | | |
| | | 31.0 - 33.5 | 0/0 | | | |
| | | 36.0 - 38.5 | 0/0 | | | |
| | | 38.5 - 40.0 | 0/0 | | | |

11/11/93
bfdTAB1

## TABLE 1.12
## VMP CONSTRUCTION DATA
## Base Fire Department
## McClellan AFB, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VMP-1 | 40.0 | – | 8 | 7.5 – 8.5 | 3.0 – 7.5 | None |
| | | | 18 | 17.5 – 18.5 | 8.5 – 17.5 | |
| | | | 28 | 27.5 – 28.5 | 18.5 – 27.5 | |
| | | | 39.5 | 39.0 – 40.0 | 28.5 – 39.0 | |

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attached to the top of each casing string. No thermocouples were installed. The surface of the VMP was completed with a flush-mount well box similar to VMP surface completions at other sites.

### 1.6.4 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- Lone Star 6-12 sand was used for filter pack material in the VMP instead of 6-9 silica sand.

## 1.7 Davis Global Communications Site (Davis Site)

### 1.7.1 Introduction

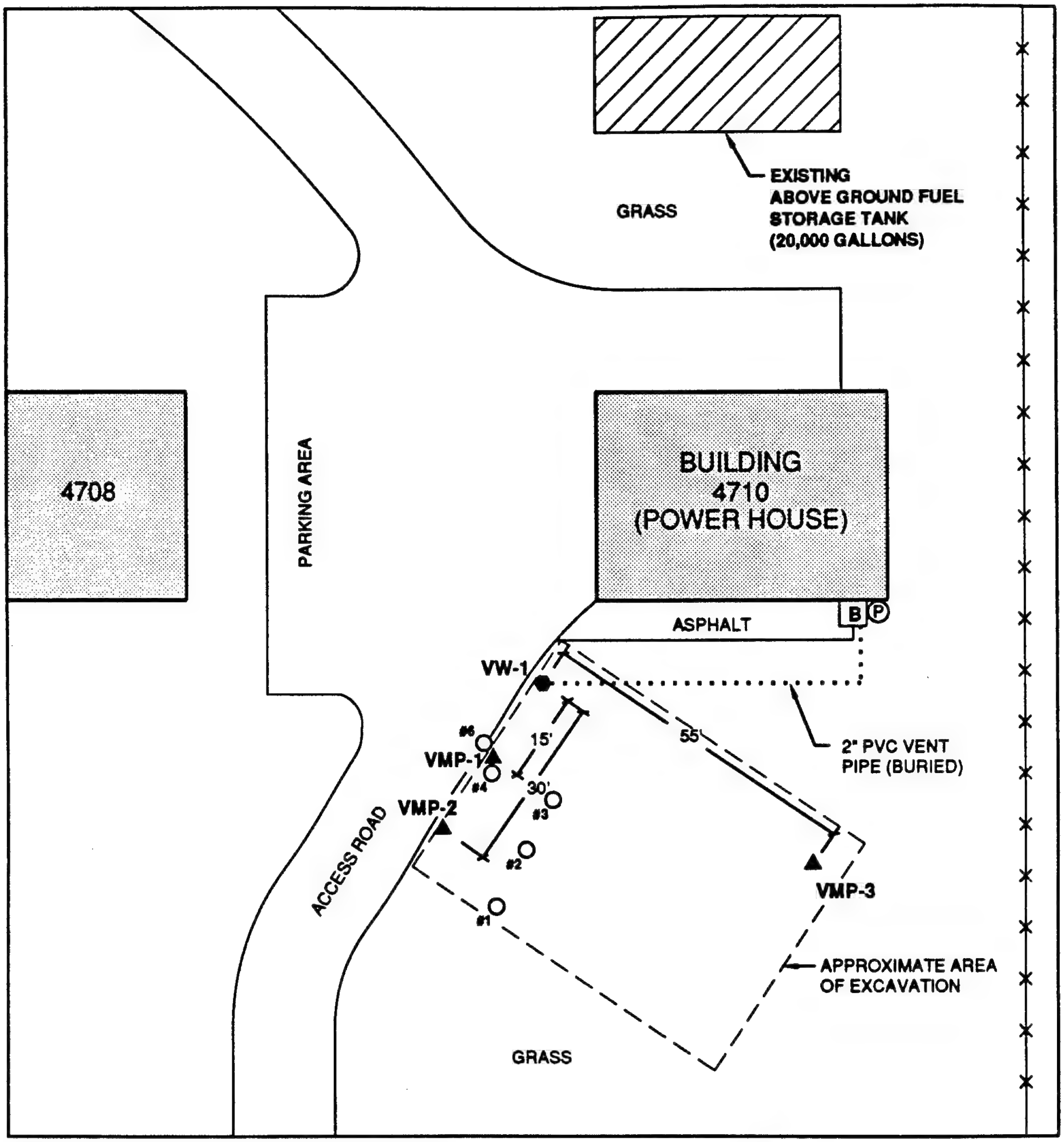
Installation of one VW and four VMPs was conducted at the Davis Site between 19 and 28 July 1993. Locations of the VW and VMPs are shown on Figure 1.15. The background VMP (VMP-4) was located approximately 1000 feet northeast of VW-1 (Figure 1.16). Borehole drilling services were provided by Beylik Drilling, Inc. of Sacramento, California. Soil sampling and well installation was directed on site by Ms. Elizabeth Rosenberg of the Engineering-Science, Inc., office in Alameda, California.

Ten boreholes were drilled at the site and five were converted to either a VW or a VMP. Five boreholes were abandoned either because contamination observed during drilling was at insufficient levels for VW and VMP siting or because borehole conditions rendered drilling difficult. Uncontaminated soils were encountered throughout the background VMP borehole. Soil samples from split-spoon and/or continuous soil samplers were collected for field OVA to determine appropriate VW and VMP screened intervals and total depths. Both a THVA and a PID were used to screen field samples. Soil samples were also collected for laboratory analysis. Table 1.13 summarizes pertinent borehole data.

### 1.7.2 Soil Profile

Figure 1.17 is a geologic cross-section of the pilot-test site using data from the VW, three VMPs, and an abandoned boring. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TRPH concentrations from laboratory analysis of soil samples, and initial oxygen levels in soil gas. The soil boring logs are included in Appendix A.

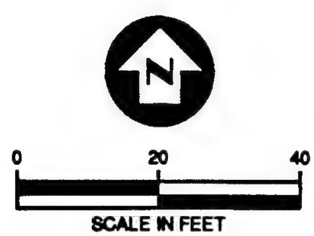
The observed soil from surface down to an average of approximately 6 feet bgs in all borings at the site is a fill composed of brown sandy clayey silt with minor amounts of gravel. Below this fill material is a more clay-rich fill material that extends to a maximum depth of 13 ft bgs where a 2-foot thick concrete pad was encountered. In all the borings, with the exception of VMP-3, these fill materials exhibited noticeable fuel odor with blue-green discoloration below 8 feet bgs.




## EXPLANATION

| | |
|---|---|
| B | BLOWER LOCATION |
| P | POWER LINE |
| ● VW-1 | VENT WELL |
| ▲ VMP-1 | VAPOR MONITORING POINT |
| #1 O | ABANDONED SOIL BORING |
| —x—x—x— | FENCE |

SOURCE: MODIFIED FROM CH2M HILL, 1993

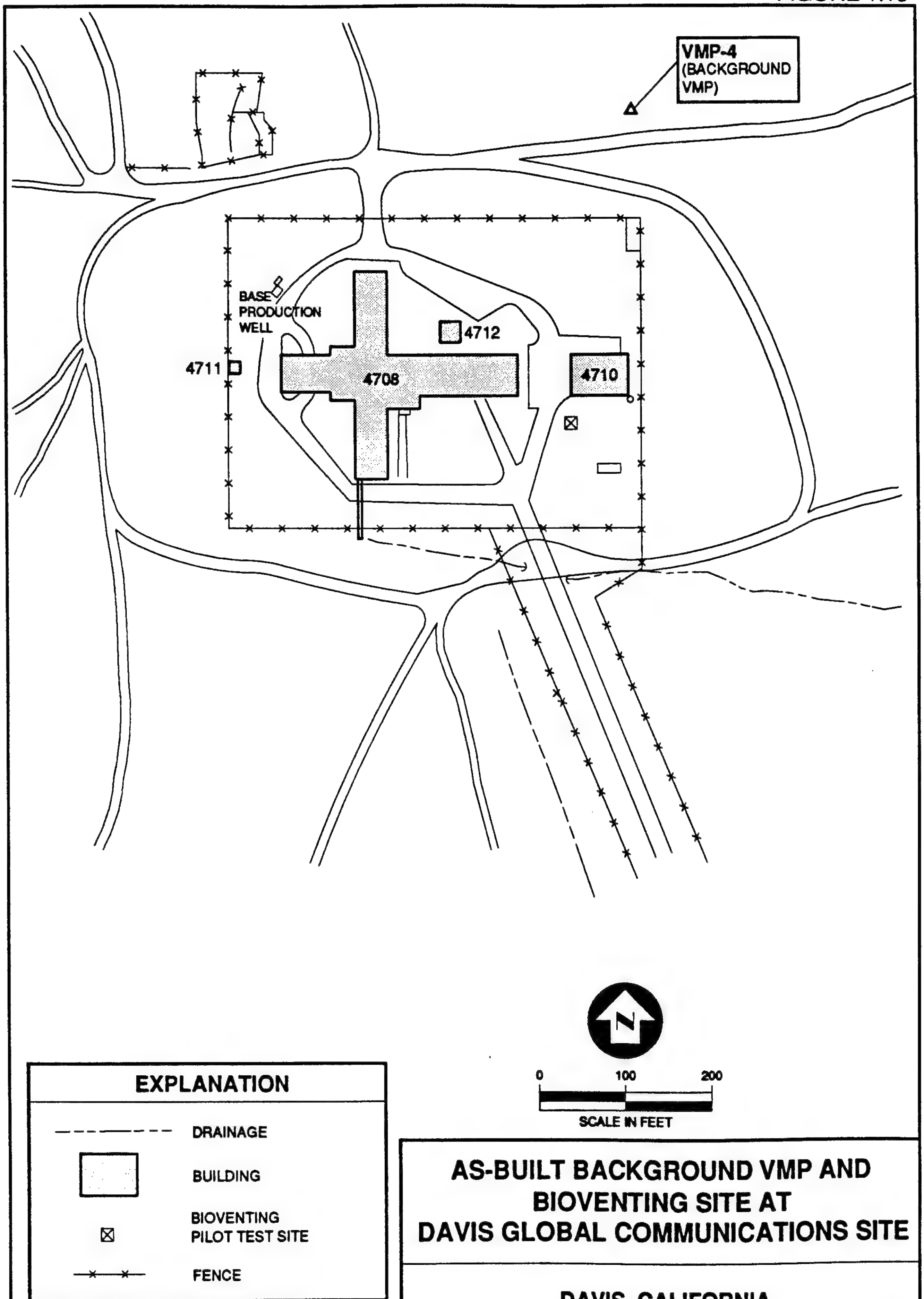



# AS-BUILT VENT WELL AND VAPOR MONITORING POINT LOCATIONS DAVIS SITE

DAVIS, CALIFORNIA

REV. 4 C257-04.DWG 01/12/94

ENGINEERING-SCIENCE, INC.




SOURCE: Modified from I T Corporation, 1992

**AS-BUILT BACKGROUND VMP AND BIOVENTING SITE AT DAVIS GLOBAL COMMUNICATIONS SITE**

**DAVIS, CALIFORNIA**

# TABLE 1.13
# BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
## Davis Global Communications Site
## Davis, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 1 | 30.0 | 2.5 – 5.0 | 4/0 | | 7/19/93 | 7/28/93 | Abandoned |
| | | 7.5 – 10.0 | 32/0 | | | | |
| | | 12.5 – 15.0 | 72/97.5 | | | | |
| | | 17.5 – 20.0 | 64/68.8 | | | | |
| | | 22.5 – 24.0 | 75/108 | | | | |
| | | 24.0 – 25.0 | 8/0 | | | | |
| | | 27.5 – 30.0 | 10/0 | | | | |
| 2 | 35.0 | 7.5 – 10.0 | 38/5 | | 7/20/93 | 7/28/93 | Abandoned |
| | | 10.0 – 12.5 | 20/12.6 | | | | |
| | | 15.0 – 16.0 | 0/35 | | | | |
| | | 16.0 – 17.5 | 14/12.4 | | | | |
| | | 20.0 – 22.5 | 8/10.2 | | | | |
| | | 22.5 – 25.0 | 32/5.0 | | | | |
| | | 25.0 – 27.5 | 24/11.7 | | | | |
| | | 30.0 – 32.5 | 24/4.5 | | | | |
| | | 32.5 – 35.0 | 36/1.2 | | | | |
| 3 | 13.0 | 2.5 – 5.0 | 8/12.2 | | 7/20/93 | 7/28/93 | Abandoned |
| | | 5.0 – 7.5 | 44/18.7 | | | | |
| | | 12.5 – 13.0 | 210/27.2 | | | | |
| 4 | 13.0 | 2.5 – 5.0 | 50/0 | | 7/20/93 | 7/28/93 | Abandoned |
| | | 5.0 – 7.5 | 320/182 | | | | |
| | | 7.5 – 10.0 | 480/263 | | | | |
| 5 | 57.5 | 2.5 – 5.0 | 45/21.6 | | 7/20/93 | 7/28/93 | VMP–1 |
| | | 7.5 – 10.0 | 42/106 | | | | |
| | | 12.5 – 15.0 | 220/202 | DAV–VMP1–15.0 | | | |
| | | 17.5 – 20.0 | 36/58.2 | | | | |
| | | 20.0 – 22.5 | 86/134 | | | | |
| | | 22.5 – 25.0 | 130/153 | | | | |
| | | 25.0 – 27.5 | 58/59.3 | | | | |
| | | 30.0 – 32.5 | 16/3.0 | | | | |
| | | 35.0 – 36.0 | 34/125 | | | | |
| | | 36.0 – 37.5 | 58/155 | | | | |
| | | 37.5 – 40.0 | 52/68.2 | | | | |
| | | 42.5 – 45.0 | 60/97.2 | | | | |
| | | 47.5 – 50.0 | 8/24.8 | | | | |
| | | 52.5 – 55.0 | 83/152 | | | | |
| | | 55.0 – 57.5 | 90/227 | | | | |
| 6 | 1.0 | not sampled | | | | | Abandoned |

01/18/94
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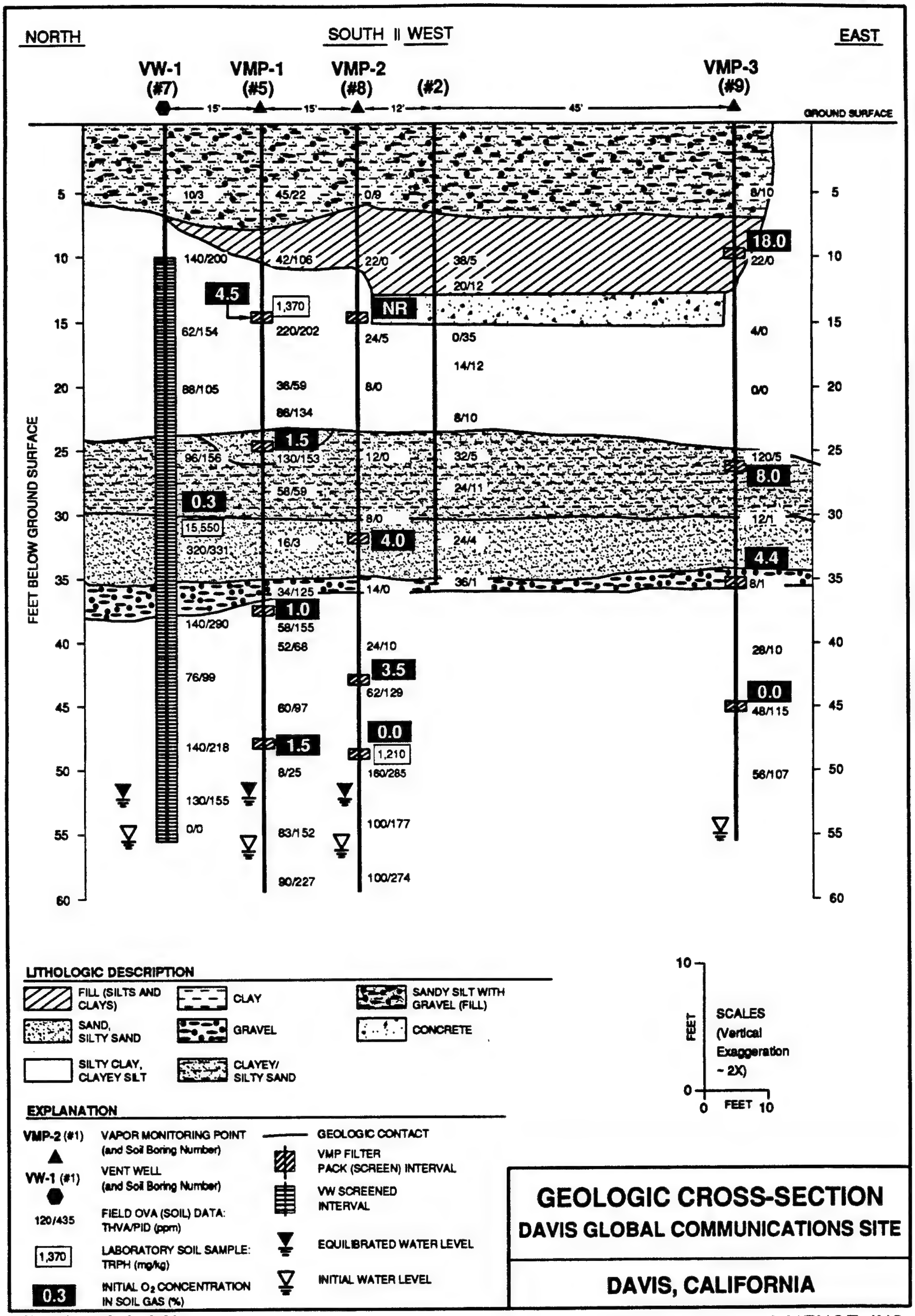
# TABLE 1.13 (continued)
# BOREHOLE, SOIL SAMPLE, AND VMP/VW SUMMARY DATA
## Davis Global Communications Site
## Davis, California

| BOREHOLE ID # | BOREHOLE TOTAL DEPTH (ft. bgs) | SOIL SAMPLE INTERVAL (ft. bgs) | THVA/PID HEADSPACE READINGS (PPM) | SOIL SAMPLE ID # | START DATE | COMPLETION DATE | COMPLETION DESIGNATION |
|---|---|---|---|---|---|---|---|
| 7 | 55.0 | 2.5 – 5.0 | 10/3 | | 7/21/93 | 7/28/93 | VW-1 |
| | | 7.5 – 10.0 | 140/200 | | | | |
| | | 12.5 – 15.0 | 62/154 | | | | |
| | | 17.5 – 20.0 | 88/105 | | | | |
| | | 22.5 – 25.0 | 96/156 | | | | |
| | | 30.0 – 32.5 | 320/331 | DAV-VW1-32.5 | | | |
| | | 36.0 – 37.5 | 140/290 | | | | |
| | | 40.0 – 42.5 | 76/99.2 | | | | |
| | | 45.0 – 47.5 | 140/218 | | | | |
| | | 50.0 – 52.5 | 130/155 | | | | |
| | | 53.5–55.0 | 0/0 | | | | |
| 8 | 57.5 | 2.5 – 5.0 | 0/8.9 | | 7/22/93 | 7/28/93 | VMP-2 |
| | | 7.5 – 10.0 | 22/0 | | | | |
| | | 12.5 – 15.0 | 24/4.7 | | | | |
| | | 17.5 – 20.0 | 8/0 | | | | |
| | | 22.5 – 25.0 | 12/0 | | | | |
| | | 27.5 – 30.0 | 8/0 | | | | |
| | | 32.5 – 35.0 | 14/0 | | | | |
| | | 37.5 – 40.0 | 24/10.2 | | | | |
| | | 42.5 – 45.0 | 62/129 | | | | |
| | | 47.5 – 50.0 | 160/285 | DAV-VMP2-50.0 | | | |
| | | 52.5 – 55.0 | 100/177 | | | | |
| | | 55.0 – 57.5 | 100/274 | | | | |
| 9 | 55.0 | 2.5 – 5.0 | 8/10.2 | | 7/22/93 | 7/28/93 | VMP-3 |
| | | 7.5 – 10.0 | 22/0 | | | | |
| | | 12.5 – 15.0 | 4/0 | | | | |
| | | 17.5 – 20.0 | 0/0 | | | | |
| | | 22.5 – 25.0 | 120/4.9 | | | | |
| | | 28.5–30.0 | 12/1 | | | | |
| | | 32.5 – 35.0 | 8/1.4 | | | | |
| | | 37.5 – 40.0 | 28/10.8 | | | | |
| | | 42.5 – 45.0 | 48/115 | | | | |
| | | 47.5 – 50.0 | 56/107 | | | | |
| 10 | 52.5 | 2.5 – 5.0 | 0/5.6 | | 7/27/93 | 7/28/93 | VMP-4 |
| | | 7.5 – 10.0 | 0/2.8 | | | | |
| | | 12.5 – 15.0 | 0/2.2 | DAV-VMP4-15.0 | | | |
| | | 17.5 – 20.0 | 0/0 | | | | |
| | | 22.5 – 25.0 | 0/1.9 | | | | |
| | | 27.5 – 30.0 | 0/0 | | | | |
| | | 32.5 – 35.0 | 0/0 | | | | |
| | | 37.5 – 40.0 | 1/0 | | | | |
| | | 42.5 – 45.0 | 0/0 | | | | |
| | | 47.5 – 50.0 | 0/0 | | | | |




**GEOLOGIC CROSS-SECTION**
**DAVIS GLOBAL COMMUNICATIONS SITE**

**DAVIS, CALIFORNIA**

REV. 5 C264-03.DWG 02/09/94

ENGINEERING-SCIENCE, INC.

In VMP-1 and VMP-2, native soils are silty clays from 10 to 24 feet bgs that are discolored black to dark blue-green from approximately 10 to 17 feet bgs. In borehole 2 (abandoned), native soils below the concrete are discolored blue-green from only 15 to 16 feet bgs.

The native soils from approximately 25 to 30 feet bgs are predominantly clayey sands. A lens of loose sand was encountered in VMP-1 from 24 to 26 feet bgs. Fine to medium-grained sand was found in all borings from approximately 30 to 35 feet bgs. This sand grades downward to an approximately one foot thick interval of basal gravel. The sand and gravel intervals exhibit extensive blue-green discoloration with a fuel odor in VW-1 and VMP-1 and minor blue-green discoloration with a mild fuel odor in parts of VMP-3.

From this gravel interval to the bottom of the boreholes, the soils are predominantly clayey silts and silty clays. Stiff clay was reported in VMP-1 below 45 feet bgs and in VW-1 below 51 feet bgs. These clays and silts are slightly stiff to stiff in parts and exhibited blue-green discoloration and noticeable fuel odor throughout.

Groundwater was encountered in all VMP/VW well borings; groundwater levels are shown on Figure 1.17. Initially encountered levels were: 54.8 feet bgs in VW-1, 56.0 feet bgs in VMP-1, 55.5 feet bgs in VMP-2, and 54.5 feet bgs in VMP-3. After approximately one day, equilibrated levels were: 51.5 feet bgs in VW-1, 52.1 feet bgs in VMP-1, and 52.5 feet bgs in VMP-2 (no equilibrated level was measured for VMP-3).

The soils encountered in the background VMP (VMP-4), located approximately 1000 feet northeast of VW-1, are similar to the soils in the vicinity of the former USTs. No discoloration or fuel odors were detected in the VMP-4 soils and no significant OVA readings were noted. Groundwater in VMP-4 was encountered at 52.5 feet bgs.

### 1.7.3 Air Injection Vent Well

One air injection VW (VW-1) was installed in a location where soils exhibited noticeable fuel-staining and odor following procedures described in the protocol document. VW-1 was installed in the northwest corner of the grassy area in the vicinity of the former USTs (Figure 1.15). Table 1.14 presents construction data, and Figure 1.3 shows construction details for the VW.

VW-1 was constructed using 4-inch ID, Schedule 40 PVC casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with size 6-12 Lone Star sand (filter pack material) from the base of the borehole at 55 feet bgs to 1 foot above the top of the screen. A small amount of size 1-C Lone Star sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval.

To prevent preferential air movement near the surface during pilot testing, a 4-foot thick annular bentonite seal was emplaced on top of the filter pack. The annulus of the well was then filled with a bentonite/cement grout. The upper 3.0 feet of annular space was left vacant for ease of connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The upper 2 feet of well casing was

# TABLE 1.14
# VMP/VW CONSTRUCTION DATA
## Davis Global Communications Site
## Davis, California

| WELL ID # | BOREHOLE TOTAL DEPTH (ft.bgs) | VW SCREEN INTERVAL (ft.bgs) | CENTER of VMP SCREEN (ft.bgs) | FILTER PACK INTERVAL(s) (ft.bgs) | BENTONITE INTERVAL(s) (ft.bgs) | GROUT INTERVAL(s) (ft.bgs) |
|---|---|---|---|---|---|---|
| VW−1 | 55.0 | 10.0 – 55.0 | – | 9.0 – 55.0 | 5.0 – 9.0 | 3.0 – 5.0 |
| VMP−1 | 57.5 | – | 15.0 | 14.5 – 15.5 | 3.0 – 14.5 | None |
| | | | 25.0 | 24.5 – 25.5 | 15.5 – 24.5 | |
| | | | 37.5 | 37.0 – 38.0 | 25.5 – 37.0 | |
| | | | 48.0 | 47.5 – 48.5 | 38.0 – 47.5 | |
| | | | | | 48.5 – 57.5 | |
| VMP−2 | 57.5 | – | 15.0 | 14.5 – 15.5 | 3.0 – 14.5 | None |
| | | | 32.0 | 31.5 – 32.5 | 15.5 – 31.5 | |
| | | | 43.0 | 42.5 – 43.5 | 32.5 – 42.5 | |
| | | | 49.0 | 48.5 – 49.5 | 43.5 – 48.5 | |
| | | | | | 49.5 – 57.5 | |
| VMP−3 | 55.0 | – | 10.0 | 9.5 – 10.5 | 3.0 – 9.5 | None |
| | | | 26.5 | 26.0 – 27.0 | 10.5 – 26.0 | |
| | | | 35.0 | 34.5 – 35.5 | 27.0 – 34.5 | |
| | | | 45.0 | 44.5 – 45.5 | 35.5 – 44.5 | |
| | | | | | 45.5 – 55.0 | |
| VMP−4 | 52.5 | – | 15.0 | 14.5 – 15.5 | 3.0 – 14.5 | None |
| | | | 30.0 | 29.5 – 30.5 | 15.5 – 29.5 | |
| | | | 40.0 | 39.5 – 40.5 | 30.5 – 39.5 | |
| | | | | | 40.5 – 52.5 | |

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completed with a 4-inch diameter Schedule 40 PVC tee and a 4-inch PVC cap. The tee was connected to the 2-inch diameter PVC pipe from the blower unit and fitted with a flow control valve to isolate the VW for sampling purposes. The surface completion of the VW consisted of a water-tight, traffic-proof, cast-iron well box (securable with hexbolts) emplaced within a 3-foot diameter concrete collar sloped away from the box for drainage.

VW-1 was connected to the blower unit by 2-inch diameter Schedule 40 PVC pipe buried in a trench. Grass was cut away and removed prior to trenching work. A trench, 4 inches wide, and 1 foot deep, was excavated from VW-1 to the location designated for the blower, and PVC pipe was laid in the trench. After securing the pipe, soil was returned to the trench and compacted, and grass was replaced over the trenched area. The subsurface PVC pipe runs 65 feet east of VW-1, then 25 feet north to the edge of Building 4710 and elbows below ground to vertical. The top of the vertical PVC pipe was cut to approximately two feet above ground surface. The above ground PVC pipe was connected directly to the portable blower unit for the initial pilot test and then to the fixed blower unit located adjacent to the well for the extended pilot test.

### 1.7.4 Vapor Monitoring Points

VMP-1 and VMP-2 were installed in a line parallel to and 4 feet southeast of the access road. VMP-1 was located 15 feet southwest of VW-1, and VMP-2 was located 30 feet southwest of VW-1. VMP-3 was located approximately 55 feet southeast of VW-1 (Figure 1.15). The wells are located along the perimeter of the border of the former underground fuel storage tank pit. The exact locations of the wells were based on field screening for hydrocarbons. All three VMPs were installed in areas of noticeable fuel odor and soil discoloration. As previously noted, the background VMP (VMP-4) was installed in uncontaminated soil approximately 1000 feet northeast of VW-1.

All VMPs were installed following procedures described in the protocol document. Table 1.14 shows construction data, and Figure 1.4 shows construction details for the VMPs. The VMPs have similar construction details. Each VMP was constructed using 0.25-inch ID, Schedule 80 PVC casing and 1-inch ID slotted screen intervals (0.020-inch slot size). Four casing strings/screens were installed in VMP-1, VMP-2, and VMP-3, and three casing strings/screens were installed in VMP-4, to provide monitoring points at variable depths, soil types, and contamination levels. The center of the screened intervals for each VMP are located as follows: 15, 25, 37.5, and 48 feet bgs for VMP-1; 15, 32, 43 and 49 feet bgs for VMP-2; 10, 26.5, 35 and 45 feet bgs for VMP-3; and 15, 30 and 40 feet bgs for VMP-4.

Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and was centered in a 1-foot thick layer of size 6-12 Lone Star sand (filter pack material) topped with a thin layer of size 1-C Lone Star sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-1, thermocouples were installed adjacent to the 15 and 48 foot screens to allow measurement of soil temperature. The surface of each VMP was completed with a flush-mount well box similar to the VW surface completion.

### 1.7.5 Blower Units

A portable 3.0-HP Roots™ positive displacement blower unit was used for the initial pilot test, powered by an on-site 230V, single-phase, 30A line provided by the base. A fixed 1.0-HP Gast™ regenerative blower unit (model R4) was installed and began operation on 27 August 1993 for the extended pilot test. This unit is powered by the same line used for the portable unit. Locations of the power line and blower are shown on Figure 1.15.

At the time of installation, the fixed blower unit was injecting approximately 54 scfm for the extended pilot test. Figure 1.5 shows the process flow and instrumentation diagram for this system. ES personnel provided an O&M data collection sheet and blower maintenance manual to base personnel. A sample copy of the data collection sheet and maintenance manual is provided in Appendix B.

### 1.7.6 Exceptions to Protocol Document Procedures

Procedures described in the protocol document related to pilot test design and construction were used with the following exceptions:

- Lone Star 6-12 sand was used for filter pack material in all VMPs and the VW instead of 6-9 silica sand.

## 2.0 SOIL, SOIL-GAS, AND SURFACE AIR SAMPLING RESULTS

### 2.1 Tank Farm #2 (TF-2)

#### 2.1.1 Soil Sample Field Analysis

Contaminated soils were identified based on field observations such as visual appearance, odor, and OVA readings. OVA readings were monitored using both a PID and a THVA on all soil samples in order to estimate the relative amount and extent of soil contamination detectable by such devices. In the low-detection range, the PID readings were generally an order of magnitude higher. In the high-detection range, it was not uncommon for the THVA to read higher than the PID (see Table 1.1).

#### 2.1.2 Soil Sample Laboratory Analysis

Soil samples were collected using a continuous split-spoon sampler lined with brass or stainless steel sleeves. The samples were preserved in the brass or stainless steel sleeves and capped with Teflon™ tape and plastic end caps. Selection of soil samples for laboratory analysis was based on field OVA readings, visual appearance, and odor. Samples were collected at VW-1, VMP-1, and VMP-2 from depths of 22.5, 20, and 21 feet bgs, respectively (see Table 1.1).

Soil samples selected for laboratory analysis were delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. Analytes for all soil samples were: total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethylbenzene, and total xylenes (BTEX); iron; total alkalinity; pH; total Kjeldahl nitrogen (TKN); total phosphorus; moisture content; and grain size distribution. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for TF-2 samples are summarized in Table 2.1. The TRPH concentrations are also included on the geologic cross section (Figure 1.2).

#### 2.1.3 Soil-Gas/Surface Air Sample Laboratory Analysis

Subsurface soil-gas samples were collected for laboratory analysis in one-liter Summa® cannisters after purging the individual casings and filter packs of at least one volume of air. The soil-gas samples were shipped to Air Toxics, Ltd. in Folsom, California for analysis of total volatile hydrocarbons as jet fuel (TVH-jf) and BTEX. Chain-of-custody forms are included in Appendix C. Soil-gas samples were collected from the vent well (VW-1) and from the screened intervals at 20 and 13 feet bgs in VMP-1 and VMP-3, respectively. Results of these analyses are summarized in Table 2.1.

Additional surface air samples were collected for laboratory analysis before and during air injection to estimate potential emissions of TVH-jf and BTEX to the atmosphere resulting from air injection during the pilot test. Two samples were collected at a surface point (SPT) located 16 feet northeast of VW-1. One sample was collected

# TABLE 2.1
# SOIL, SOIL–GAS, and SURFACE AIR ANALYTICAL RESULTS
# Tank Farm #2
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION – DEPTH (WELL NUMBER AND FEET BELOW GROUND SURFACE) | | |
|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | **VW1–22.5** | **VMP1–20** | **VMP2–21** |
| TRPH | E418.1 | (mg/kg) | 100 | <12 | <12 |
| Benzene | SW8020 | (mg/kg) | <0.001 | 0.004 | <0.03 |
| Toluene | SW8020 | (mg/kg) | 0.027 | 0.28 | 4.4 |
| Ethylbenzene | SW8020 | (mg/kg) | 0.013 | 0.054 | 0.29 |
| Xylenes, Total | SW8020 | (mg/kg) | 0.11 | 0.2 | 1.4 |
| **Soil Inorganics:** | | | **VW1–22.5** | **VMP1–20** | **VMP2–21** |
| Iron | SW7380 | (mg/kg dry wt.) | 28,900 | 28,700 | 22,600 |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | 68 | 160 | 120 |
| pH | SW9045 | (units) | 8.1 | 7.6 | 7.8 |
| TKN | E351.2 | (mg/kg dry wt.) | 56 | 46 | 39 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 1,100 | 1,300 | 1,000 |
| **Soil Physical Parameters:** | | | **VW1–22.5** | **VMP1–20** | **VMP2–21** |
| Moisture Content | ASTM D2216 | (% by wt.) | 13 | 17 | 16 |
| Gravel | ASTM D422 | (% by wt.) | 0.0 | 0.0 | 0.0 |
| Sand | ASTM D422 | (% by wt.) | 29.4 | 46.2 | 39.9 |
| Silt | ASTM D422 | (% by wt.) | 68.8 | 45.7 | 59.8 |
| Clay | ASTM D422 | (% by wt.) | 1.8 | 8.1 | 0.9 |
| **Soil–Gas Hydrocarbons:** | | | **VW1** | **VMP1–20** | **VMP3–13** |
| TVH–jf | EPA TO–3 | (ppmv) | 31,000 | 23,000 | 34,000 |
| Benzene | EPA TO–3 | (ppmv) | <1.0 | <1.0 | <2.1 |
| Toluene | EPA TO–3 | (ppmv) | 58 | 24 | <2.1 |
| Ethylbenzene | EPA TO–3 | (ppmv) | 5.3 | 7.5 | 11 |
| Xylenes, Total | EPA TO–3 | (ppmv) | 61 | 12 | 16 |
| **Surface Air Hydrocarbons:** | | | **SPT7A (a)** | **SPT7B (b)** | |
| TVH–jf | EPA TO–3 | (ppmv) | 0.11 | <0.021 | |
| Benzene | EPA TO–3 | (ppmv) | <0.002 | <0.002 | |
| Toluene | EPA TO–3 | (ppmv) | 0.003 | 0.004 | |
| Ethylbenzene | EPA TO–3 | (ppmv) | <0.002 | <0.002 | |
| Xylenes, Total | EPA TO–3 | (ppmv) | <0.002 | <0.002 | |

NOTES:
TRPH – Total recoverable petroleum hydrocarbons
TVH–jf – Total volatile hydrocarbons as jet fuel
TKN – Total Kjeldahl nitrogen
(a) collected prior to air injection
(b) collected during air injection

<5.0 – below given detection limit
NA – Not Analyzed
CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram
ppmv – Parts per million by volume

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prior to the start of air injection (sample SPT7A) and one sample 5 hours after the start of and during air injection (sample SPT7B). The results of these surface samples analyses are shown in Table 2.1 and discussed in Section 3.1.5.

### 2.1.4 Field QA/QC Results

No Quality Assurance/Quality Control (QA/QC) soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.1.5 Subsurface Contamination

The extent of the hydrocarbon contamination at the site remains unknown. All boreholes drilled at the site encountered evidence of hydrocarbon contamination. OVA readings greater than 2,000 ppmv were measured in all boreholes. Except for borehole number 4 (completed as VMP-3), the highest OVA readings were recorded at approximately 20 feet bgs, near the contact between the clayey silt or clay fill and an underlying clayey sand interval. In borehole number 4, the highest reading was at approximately 10 feet bgs, near the base of the fill, although significantly high readings continued to approximately 20 feet bgs at the top of the clayey sand interval. Fuel odors were noted in all borings to depths of approximately 21 feet bgs. Blue-green discoloration, an additional indicator of soil contamination by fuels, was noted at depths coincident with the higher OVA readings.

Laboratory analysis of soil and soil-gas samples documented hydrocarbon contamination in all wells. All soil-gas samples had TVH-jf concentrations exceeding 20,000 ppmv, indicating that the vadose zone has significant volatile fuel hydrocarbon contamination. Although TRPH was only detected in the soil sample taken at the vent well (VW-1) at 100 mg/kg, the soils at the site have likely produced a heterogeneous contaminant distribution and the TRPH laboratory test analyzes only for the heavier, less volatile fraction in the range of jet fuel. Supporting evidence for this interpretation is provided by the widely varying field OVA and laboratory analytical results for soil samples, but consistent results for soil-gas samples. Benzene was not detected in significant concentrations in soil or soil-gas samples, although other BTEX components were detected.

### 2.1.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) related to soil and soil-gas sampling were used with the following exceptions:

- Soil samples were screened in the field (OVA readings) using both a THVA and a PID in order to compare data from both devices.
- Surface air samples were collected before and during the air permeability (AP) test and analyzed for TVH-jf and BTEX. This sampling was performed at the request of McClellan AFB and the Sacramento Metropolitan Air Quality Management District (SMAQMD) to evaluate potential atmospheric emissions during the pilot test.

## 2.2 Tank Farm #4 (TF-4)

### 2.2.1 Soil Sample Field Analysis

Contaminated soils were identified based on procedures described in Section 2.1.1. At Tank Farm #4 (TF-4), OVA readings using the PID and THVA were generally of the same order of magnitude (see Table 1.3).

### 2.2.2 Soil Sample Laboratory Analysis

Soil samples were collected and selected for laboratory analysis using procedures described in Section 2.1.2. Samples were collected at VW-1, VMP-1, and VMP-2 from depths of 12.5 feet bgs, 17.5 feet bgs, and 20 feet bgs respectively (see Table 1.3).

Soil samples selected for laboratory analysis were delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. Analytes for all soil samples were: total petroleum hydrocarbons as gasoline (TPH-g); BTEX; iron; total alkalinity; pH; TKN; total phosphorus; moisture content; and grain size distribution. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for TF-4 samples are summarized in Table 2.2. The TPH-g concentrations are also included on the geologic cross section (Figure 1.7).

### 2.2.3 Soil-Gas Sample Laboratory Analysis

Subsurface soil-gas samples were collected using procedures described in Section 2.1.3. Soil-gas samples were collected from the vent well (VW-1) and from the screened intervals at 17.5 and 20 feet bgs in VMP-1 and VMP-3, respectively. The soil-gas samples were analyzed for total volatile hydrocarbons as gasoline (TVH-g) and BTEX. Results of these analyses are summarized in Table 2.2.

### 2.2.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.2.5 Subsurface Contamination

The extent of the hydrocarbon contamination at the site remains unknown. All boreholes drilled encountered some evidence of hydrocarbon contamination, though the contamination at VMP-2 and VMP-3 seems limited and of a lower magnitude based on both field OVA readings and laboratory analysis of soil samples. OVA readings greater than 1,000 ppmv were only measured in VW-1 and VMP-1. These readings were recorded between 10 and 18 feet bgs (Figure 1.7), in the native soils immediately underlying the fill material. Except for VMP-3, fuel odor and blue-green discoloration were noted in all boreholes converted to either the VW or VMPs. Two boreholes were abandoned due to insufficient evidence of contamination.

Laboratory analysis of soil and soil-gas samples documented hydrocarbon contamination in VW-1 and VMP-1. Soil results indicated less than 100 mg/kg TPH-g and minor amounts of the BTEX components. No benzene was detected in any soil

# TABLE 2.2
# SOIL and SOIL GAS ANALYTICAL RESULTS
# Tank Farm #4
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION – DEPTH (well number and feet below ground surface) | | |
|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | **VW1–12.5** | **VMP1–17.5** | **VMP2–20** |
| TPH–g | mod. 8015 | (mg/kg) | 46 | 76 | <0.06 |
| Benzene | SW8020 | (mg/kg) | <0.05 | <0.05 | <0.0003 |
| Toluene | SW8020 | (mg/kg) | <0.05 | 0.062 | <0.0003 |
| Ethylbenzene | SW8020 | (mg/kg) | <0.05 | <0.05 | <0.0003 |
| Xylenes, Total | SW8020 | (mg/kg) | 2.7 | 0.47 | <0.0007 |
| **Soil Inorganics:** | | | **VW1–12.5** | **VMP1–17.5** | **VMP2–20** |
| Iron | SW7380 | (mg/kg dry wt.) | 27,200 | 21,900 | 26,600 |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | 68 | <46 | 210 |
| pH | SW9045 | (units) | 7.0 | 7.3 | 7.9 |
| TKN | E351.2 | (mg/kg dry wt.) | 130 | 44 | 49 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 110 | 330 | 7.8 |
| **Soil Physical Parameters:** | | | **VW1–12.5** | **VMP1–17.5** | **VMP2–20** |
| Moisture Content | ASTM D2216 | (% by wt.) | 27 | 13 | 22 |
| Gravel | ASTM D422 | (% by wt.) | 0.0 | 0.0 | 0.0 |
| Sand | ASTM D422 | (% by wt.) | 12.4 | 26.7 | 4.0 |
| Silt | ASTM D422 | (% by wt.) | 81.1 | 68.6 | 83.4 |
| Clay | ASTM D422 | (% by wt.) | 6.5 | 4.7 | 12.6 |
| **Soil Gas Hydrocarbons:** | | | **VW1** | **VMP1–17.5** | **VMP3–20** |
| TVH–g | EPA TO–3 | (ppmv) | 1,900 | 5,200 | 10 |
| Benzene | EPA TO–3 | (ppmv) | <0.11 | <0.53 | <0.002 |
| Toluene | EPA TO–3 | (ppmv) | <0.11 | <0.53 | 0.011 |
| Ethylbenzene | EPA TO–3 | (ppmv) | 4.8 | 11 | <0.002 |
| Xylenes, Total | EPA TO–3 | (ppmv) | 5.0 | 12 | 0.021 |

NOTES:

TPH–g – Total petroleum hydrocarbons as gasoline
TVH–g – Total volatile hydrocarbons as gasoline
TKN – Total Kjeldahl nitrogen
ppmv – Parts per million by volume

<5.0 – below given detection limit
NA – Not Analyzed
CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram

02/02/94
tf4tab22

samples. Soil-gas results indicated only moderate levels of TVH-g contamination in VW-1 and VMP-1 (1,900 ppmv and 5,200 ppmv, respectively). No benzene was detected in any soil-gas samples.

The total extent of the contamination is unknown. However, the results summarized above show contamination is present in moderate levels around VW-1 and VMP-1. The results suggest a contamination interval at approximately 10 to 20 feet bgs and both a heterogeneous and localized contaminant distribution, consistent with the results found in previous investigations. In addition, historically both jet fuel and gasoline were stored at the site and it is unknown if one fuel type or a combination of fuel types is responsible for the contamination. The laboratory analytical method used for the soil and soil-gas samples collected during this investigation primarily detects gasoline components.

### 2.2.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to soil and soil-gas sampling were used with the following exceptions:

- Soil samples were screened in the field (OVA readings) using both a THVA and a PID in order to compare data from both devices.
- Because the contamination at the site may have primarily been the result of gasoline leaks, soil samples were analyzed for TPH-g (using modified EPA 8015) instead of TRPH (EPA 418.1). For the same reason, soil-gas samples were analyzed for TVH-g instead of TVH-jf.

## 2.3 SA 6

### 2.3.1 Soil Sample Field Analysis

During the field investigation at SA 6 by ES, contaminated soils were identified based on procedures described in Section 2.1.1. OVA readings using the PID were generally higher than the THVA readings (see Table 1.5).

### 2.3.2 Soil Sample Laboratory Analysis

During the field investigation at SA 6 by ES, soil samples were collected and one sample was selected for laboratory analysis using procedures described in Section 2.1.2. The sample for lab analysis was collected at VMP-1 from a depth of approximately 17.5 feet bgs (see Table 1.5).

The soil sample selected for laboratory analysis was delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. Analytes for the soil sample were: TPH-g; BTEX; iron; total alkalinity; pH; TKN; total phosphorus; moisture content; and grain size distribution. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for the SA 6 sample collected by ES and the samples previously collected during the February 1993 investigation by Radian Corporation are summarized in Table 2.3a and Table 2.3b, respectively.

# TABLE 2.3a
# SOIL and SOIL GAS ANALYTICAL RESULTS
# SA 6
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION – DEPTH (WELL NUMBER AND FEET BELOW GROUND SURFACE) | | |
|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | | VMP1–17.5 | |
| TPH–g | mod. 8015 | (mg/kg) | | 1,210 | |
| Benzene | SW8020 | (mg/kg) | | 4.2 | |
| Toluene | SW8020 | (mg/kg) | | 18 | |
| Ethylbenzene | SW8020 | (mg/kg) | | 14 | |
| Xylenes, Total | SW8020 | (mg/kg) | | 27 | |
| **Soil Inorganics:** | | | | VMP1–17.5 | |
| Iron | SW7380 | (mg/kg dry wt.) | | 28,400 | |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | | 71 | |
| pH | SW9045 | (units) | | 8.0 | |
| TKN | E351.2 | (mg/kg dry wt.) | | <20 | |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | | 590 | |
| **Soil Physical Parameters:** | | | | VMP1–17.5 | |
| Moisture Content | ASTM D2216 | (% by wt.) | | 17 | |
| Gravel | ASTM D422 | (% by wt.) | | 0.8 | |
| Sand | ASTM D422 | (% by wt.) | | 76.7 | |
| Silt | ASTM D422 | (% by wt.) | | 12.7 | |
| Clay | ASTM D422 | (% by wt.) | | 9.7 | |
| **Soil Gas Hydrocarbons:** | | | VW–18 (a) | VW–19 (a) | VPN20–24 (a,b) |
| TVH–g | EPA TO–3 | (ppmv) | 2,300 | 55 | 13,000 |
| Benzene | EPA TO–3 | (ppmv) | 40 | <0.004 | 38 |
| Toluene | EPA TO–3 | (ppmv) | 49 | 0.13 | 35 |
| Ethylbenzene | EPA TO–3 | (ppmv) | 6.0 | 0.051 | 6.6 |
| Xylenes, Total | EPA TO–3 | (ppmv) | 50 | 0.35 | 22 |
| **Soil Gas Hydrocarbons:** | | | VW–18 (c) | VMP1–17 (c) | |
| TVH–g | EPA TO–3 | (ppmv) | 14,000 | 130,000 | |
| Benzene | EPA TO–3 | (ppmv) | 130 | 490 | |
| Toluene | EPA TO–3 | (ppmv) | 140 | 320 | |
| Ethylbenzene | EPA TO–3 | (ppmv) | 9.4 | 34 | |
| Xylenes, Total | EPA TO–3 | (ppmv) | 130 | 170 | |

NOTES:

TPH–g – Total petroleum hydrocarbons as gasoline
TVH–g – Total volatile hydrocarbons as gasoline
TKN – Total Kjeldahl nitrogen
(a) Sample collected on 7 July 1993
(b) VPN–20 was previously designated as VW–7
(c) Sample collected on 30 August 1993

<5.0 – below given detection limit
NA – Not Analyzed
CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram
ppmv – Parts per million by volume

02/02/94
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# TABLE 2.3b
# SOIL and SOIL GAS ANALYTICAL RESULTS [a]
# SA 6
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION – DEPTH (WELL NUMBER AND FEET BELOW GROUND SURFACE) | | | |
|---|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | **VW18–15** | **VW18–39.9** | **VW18–50.8** | **VW18–80.2** |
| TPH–g | mod. 8015 | (mg/kg) | 0.38 | 0.37 | NR | NR |
| Benzene | SW8020 | (mg/kg) | NR | 0.013 | NR | NR |
| Toluene | SW8020 | (mg/kg) | 0.01 | 0.0096 | 0.0096 | 0.0073 |
| Ethylbenzene | SW8020 | (mg/kg) | NR | NR | NR | NR |
| Xylenes, Total | SW8020 | (mg/kg) | 0.024 | NR | 0.015 | NR |
| **Soil Inorganics:** | | | **VPN20–50 (b)** | **VW18–50.8** | **VW19–51.5** | |
| Iron | SW6010 | (mg/kg dry wt.) | 29,000 | 33,000 | 33,000 | |
| Total Alkalinity | E310.1 | (mg/kg as CaCO3) | 86 | 52 | 69 | |
| pH | SW9040 | (units) | 8.4 | 6.0 | 7.9 | |
| TKN | E351.4 | (mg/kg dry wt.) | 85 | 140 | 85 | |
| Total Phosphorus | E365.3 | (mg/kg dry wt.) | 1,400 | 1,100 | 1,100 | |
| **Soil Gas Contaminants:** | | | **VPN20–20** | **VPN20–40** | **VW18–20** | **VW18–50** |
| n–octane | EPA TO–14 | (ppmv) | 2 | 5.1 | 580 | NR |
| Cyclohexane | EPA TO–14 | (ppmv) | NR | 12 | 3,200 | 840 |
| Trimethylbenzenes | EPA TO–14 | (ppmv) | 0.162 | 7.7 | 185 | 41 |
| Benzene | EPA TO–14 | (ppmv) | NR | 6 | 630 | 98 |
| Toluene | EPA TO–14 | (ppmv) | NR | 0.36 | 1,400 | 610 |
| Ethylbenzene | EPA TO–14 | (ppmv) | NR | 3.2 | 150 | 110 |
| Xylenes | EPA TO–14 | (ppmv) | NR | 2.91 | 520 | 520 |
| Chloroform | EPA TO–14 | (ppmv) | 0.02 | 0.21 | 17 | NR |
| TCE | EPA TO–14 | (ppmv) | 0.62 | NR | NR | NR |
| PCE | EPA TO–14 | (ppmv) | 0.13 | NR | NR | NR |
| 1,2–dichloroethane | EPA TO–14 | (ppmv) | NR | 3.9 | NR | NR |
| **Soil Gas Contaminants:** | | | **VW18–80** | **VW19–20** | **VW19–82** | **VW19–100** |
| n–octane | EPA TO–14 | (ppmv) | 180 | 200 | 9.5 | 7.9 |
| Cyclohexane | EPA TO–14 | (ppmv) | 450 | 960 | 110 | 150 |
| Trimethylbenzenes | EPA TO–14 | (ppmv) | 89 | 26.3 | 8.4 | NR |
| Benzene | EPA TO–14 | (ppmv) | 43 | 38 | 0.66 | 0.61 |
| Toluene | EPA TO–14 | (ppmv) | 190 | 330 | 1.2 | NR |
| Ethylbenzene | EPA TO–14 | (ppmv) | 43 | 33 | 0.55 | NR |
| Xylenes | EPA TO–14 | (ppmv) | 23.2 | 110 | 2.5 | NR |
| Chloroform | EPA TO–14 | (ppmv) | 2.6 | 4.5 | NR | 0.88 |
| TCE | EPA TO–14 | (ppmv) | NR | NR | 0.16 | 0.27 |
| PCE | EPA TO–14 | (ppmv) | NR | NR | NR | NR |
| 1,2–dichloroethane | EPA TO–14 | (ppmv) | NR | NR | NR | NR |

**NOTES:**
TPH–g – Total petroleum hydrocarbons as gasoline
TKN – Total Kjeldahl nitrogen
ppmv – Parts per million by volume
(a) Source: Radian Corporation, 1993b
(b) VPN–20 was previously designated as VW–7

CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram
NR – Not Reported
NA – Not Analyzed

02/02/94
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### 2.3.3 Soil-Gas Sample Laboratory Analysis

During the field investigation by ES, subsurface soil-gas samples were collected using procedures described in Section 2.1.3. These soil-gas samples were collected from both vent wells (VW-18 and VW-19) and from the screened intervals at 17 and 24 feet bgs in VMP-1 and VPN-20, respectively, and were analyzed for TVH-g and BTEX. The results of laboratory analyses for the soil-gas samples collected by ES, and the downhole soil-gas samples collected while drilling during the February 1993 investigation by Radian Corporation, are summarized in Table 2.3a and Table 2.3b, respectively. As shown in Table 2.3a, an additional initial soil-gas sample was collected at VW-18 at a later date because field data indicated that a leak may have occurred during collection of the first initial sample (no blower operations occurred in the intervening period). Evidence for this suspicion is confirmed by the lab results for this second soil-gas sample, which indicated much higher TVH-g and BTEX concentrations, and the results from the second sample should be considered representative of initial site conditions.

### 2.3.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.3.5 Subsurface Contamination

The extent of the hydrocarbon contamination at the site remains unknown. Both of the deep boreholes drilled by ES which were converted to VMPs encountered evidence of hydrocarbon contamination; OVA readings greater than 2,000 ppmv were measured, fuel odors were noted, and blue-green discoloration was observed. The highest OVA readings in each boring were recorded from approximately 15 to 25 ft bgs, coinciding with the clayey sand and silt interval immediately above the clay interval that begins at 25 feet bgs (Figure 1.7). However, the soil sample submitted for laboratory analysis was collected from a thin silty clay bed within the sand/silt interval.

Laboratory analysis of soil and soil-gas samples documented hydrocarbon contamination in all wells. Although the Radian investigation in February 1993 found very limited soil contamination in VW-18 and VW-19, significant levels of TPH-g and BTEX were detected in the single soil sample collected during the ES field investigation at VMP-1, located between VW-18 and VW-19. The contaminant levels at VMP-1 at 17 feet bgs were: 1,210 mg/kg TPH-g, 4.2 mg/kg benzene, 18 mg/kg toluene, 14 mg/kg ethylbenzene, and 27 mg/kg total xylenes.

In soil-gas samples, with the exception of VW-19, significant levels of TVH-g and BTEX were detected at all sampled wells. Although the soil-gas sample collected by ES at VW-19 had low levels of TVH-g and BTEX, this is likely the result of sampling over a very long screened interval (85 feet). Downhole soil-gas samples collected at discrete depths during drilling of VW-19 indicated higher levels of contamination (see Table 2.3b). The maximum contaminant levels for soil gas were: 130,000 ppmv TPH-g (VMP1-17), 630 ppmv benzene (VW18-20), 1,400 ppmv toluene (VW18-20), 150 ppmv ethylbenzene (VW18-20), and 520 ppmv total xylenes (VW18-20). The sampling depth in VW18-20, which is the location of the highest BTEX concentrations in soil-gas at the

site, corresponds to the same interval where the highest OVA readings were measured (Table 1.1).

### 2.3.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to soil and soil-gas sampling were used with the following exceptions:

- Soil samples were screened in the field (OVA readings) using both a THVA and a PID in order to compare data from both devices.
- Because the contamination at the site was likely the result of gasoline leaks, soil samples were analyzed for TPH-g (using modified EPA 8015) instead of TRPH (EPA 418.1). For the same reason, soil-gas samples were analyzed for TVH-g instead of TVH-jf.

## 2.4 PRL T-46

### 2.4.1 Soil Sample Field Analysis

Contaminated soils were identified based on procedures described in Section 2.1.1. At PRL T-46, OVA readings using the PID were consistently higher than readings using the THVA (see Table 1.7).

### 2.4.2 Soil Sample Laboratory Analysis

Soil samples were collected and selected for laboratory analysis using procedures described in Section 2.1.2. Samples were collected at VW-1, VMP-1, and VMP-2 from depths of 17.5, 10, and 12.5 feet bgs, respectively (see Table 1.7).

Soil samples selected for laboratory analysis were delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. Analytes for all soil samples were: TRPH; BTEX; iron; total alkalinity; pH; TKN; total phosphorus; moisture content; and grain size distribution. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for PRL T-46 samples are summarized in Table 2.4. The TRPH concentrations are also included on the geologic cross section (Figure 1.12).

### 2.4.3 Soil-Gas Sample Laboratory Analysis

Subsurface soil-gas samples were collected using procedures described in Section 2.1.3. Soil-gas samples were collected from the vent well (VW-1) and from the screened interval at 10 feet bgs in both VMP-1 and VMP-3. The soil-gas samples were analyzed for TVH-jf and BTEX. Results of these analyses are summarized in Table 2.4.

### 2.4.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

# TABLE 2.4
# SOIL and SOIL GAS ANALYTICAL RESULTS
# PRL T−46
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION − DEPTH (well number and feet below ground surface) | | |
|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | **VW1−17.5** | **VMP1−10** | **VMP2−12.5** |
| TRPH | E418.1 | (mg/kg) | 5,280 | 570 | 3,320 |
| Benzene | SW8020 | (mg/kg) | <0.002 | <0.007 | <0.004 |
| Toluene | SW8020 | (mg/kg) | <0.002 | <0.007 | <0.004 |
| Ethylbenzene | SW8020 | (mg/kg) | 0.01 | 2.82 | <0.004 |
| Xylenes, Total | SW8020 | (mg/kg) | 0.027 | 3.4 | 0.2 |
| **Soil Inorganics:** | | | **VW1−17.5** | **VMP1−10** | **VMP2−12.5** |
| Iron | SW7380 | (mg/kg dry wt.) | 24,300 | 15,800 | 23,800 |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | <51 | <53 | 85 |
| pH | SW9045 | (units) | 7.3 | 7.2 | 7.6 |
| TKN | E351.2 | (mg/kg dry wt.) | 57 | 32 | 60 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 4.7 | 6.2 | 6.7 |
| **Soil Physical Parameters:** | | | **VW1−17.5** | **VMP1−10** | **VMP2−12.5** |
| Moisture Content | ASTM D2216 | (% by wt.) | 21 | 24 | 19 |
| Gravel | ASTM D422 | (% by wt.) | 0.0 | 0.0 | 0.0 |
| Sand | ASTM D422 | (% by wt.) | 44.9 | 90.6 | 20.2 |
| Silt | ASTM D422 | (% by wt.) | 52.5 | 8.5 | 75.3 |
| Clay | ASTM D422 | (% by wt.) | 3.5 | 0.9 | 4.5 |
| **Soil Gas Hydrocarbons:** | | | **VW1** | **VMP1−10** | **VMP3−10** |
| TVH−jf | EPA TO−3 | (ppmv) | 1,900 | 19,000 | 600 |
| Benzene | EPA TO−3 | (ppmv) | <0.0051 | <1.0 | <0.052 |
| Toluene | EPA TO−3 | (ppmv) | <0.0051 | <1.0 | <0.052 |
| Ethylbenzene | EPA TO−3 | (ppmv) | 2.5 | 7.0 | 0.31 |
| Xylenes, Total | EPA TO−3 | (ppmv) | 2.8 | 2.0 | 0.71 |

NOTES:
TRPH − Total recoverable petroleum hydrocarbons
TVH−jf − Total volatile hydrocarbons as jet fuel
TKN − Total Kjeldahl nitrogen
ppmv − Parts per million by volume

<5.0 − below given detection limit
NA − Not Analyzed
CaCO3 − Calcium carbonate
mg/kg − milligrams per kilogram

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02/02/94

### 2.4.5 Subsurface Contamination

The extent of the hydrocarbon contamination at the site remains unknown. All boreholes drilled at the site encountered evidence of hydrocarbon contamination. OVA readings greater than 1,000 ppmv were measured in VW-1 and VMP-1. The highest OVA readings in each boring were generally recorded within the upper 25 feet bgs. This corresponds to the zone of interbedded to interfingered sands, silts, and clays. Fuel odors and blue-green discolorations were often noted at depths coincident with the highest OVA readings in each borehole.

Laboratory analysis of soil and soil-gas samples documented hydrocarbon contamination in all wells. The maximum contaminant levels in soil were: 5,280 mg/kg TRPH (VW-1), 2.82 mg/kg ethylbenzene (VMP1-10), and 3.4 mg/kg total xylenes (VMP1-10). The maximum contaminant levels in soil gas were: 19,000 ppmv TVH-jf (VMP1-10), 7.0 ppmv ethylbenzene (VMP1-10), and 2.8 ppmv total xylenes (VW-1). Benzene and toluene were not detected in any soil or soil-gas samples. These results are consistent with the results from previous investigations (see Part I, Section 2.4.4).

### 2.4.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to soil and soil-gas sampling were used with no significant exceptions.

## 2.5 Building 720

Although the Building 720 site was initially proposed for a bioventing pilot test (see Part I, Section 3.1.5), unfavorable conditions for bioventing were encountered during an initial soil-gas survey at the site and during subsequent drilling, and the site was not recommended for a bioventing pilot test.

The recommendation was based on the following reasons:

- The most contaminated interval (above approximately 8 feet bgs) appeared to be saturated with water or free product during the initial soil-gas survey and during drilling. The saturation of the interval would likely prevent sufficient air-filled porosity for venting to be effective. In addition, no soil-gas samples could be withdrawn; therefore, monitoring of the site would not be possible.
- The oxygen levels in soil gas directly below a hardpan layer encountered at 7.5 to 8.5 feet bgs were too high (approximately 10% by volume) for venting to accelerate the natural biodegradation process. On 20 July 1993, soil-gas readings at VMP1-9 using field instrumentation were: 10.5 percent $O_2$, 7.0 percent $CO_2$, and 180 ppmv TVH.

A description of the sample analysis and subsurface contamination encountered during the limited site survey is discussed below.

### 2.5.1 Soil Sample Field Analysis

Contaminated soils were identified based on procedures described in Section 2.1.1. OVA readings were monitored using a PID on all soil samples in order to estimate the relative amount and extent of soil contamination detectable by such a device (see Table

1.9). Due to equipment trouble, no OVA readings were taken using the THVA at Building 720.

### 2.5.2 Soil Sample Laboratory Analysis

One soil sample was collected at VMP-1 from a depth of 6 feet bgs (see Table 1.9) and selected for laboratory analysis using procedures described in Section 2.1.2. This soil sample selected for laboratory analysis was delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. Analytes for this soil sample were: TRPH; BTEX; iron; total alkalinity; pH; TKN; total phosphorus; moisture content; and grain size distribution. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for the Building 720 sample are summarized in Table 2.5.

### 2.5.3 Soil-Gas Sample Laboratory Analysis

Because of the inability to withdraw soil gas from the tight and/or moist soils encountered at the most contaminated interval at the site, no subsurface soil-gas samples were collected for laboratory analysis.

### 2.5.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.5.5 Subsurface Contamination

The extent of the hydrocarbon contamination at the site remains unknown. Due to unfavorable site conditions, only a limited field investigation was performed, which consisted of drilling one borehole and converting it to a VMP (VMP-1). Laboratory analysis of the soil sample collected from VMP-1 at 6 feet bgs documented significant hydrocarbon contamination (3,800 mg/kg TRPH). No benzene was detected. OVA readings and visual observations of soil suggest that contamination may extend below the layer of hardpan which occurs at 7.5 to 8.5 feet bgs. However, only the upper one foot of soil immediately below the hard pan layer exhibited evidence of hydrocarbon contamination.

### 2.5.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to soil and soil-gas sampling were used with the following exception:

- No soil-gas samples could be collected from the VMP in the most contaminated zone because of tight soil conditions.

## 2.6 Base Fire Department (Background Well)

### 2.6.1 Soil Sample Field Analysis

Soil screening procedures for the background well were identical to those used at all other sites and described in Section 2.1.1. All OVA readings using a PID and THVA

# TABLE 2.5
# SOIL and SOIL GAS ANALYTICAL RESULTS
# Building 720
# McClellan AFB, California

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION – DEPTH (well number and feet below ground surface) |
|---|---|---|---|
| **Soil Hydrocarbons:** | | | VMP1–6 |
| TRPH | E418.1 | (mg/kg) | 3,800 |
| Benzene | SW8020 | (mg/kg) | <0.2 |
| Toluene | SW8020 | (mg/kg) | <0.2 |
| Ethylbenzene | SW8020 | (mg/kg) | <0.2 |
| Xylenes, Total | SW8020 | (mg/kg) | 8.2 |
| **Soil Inorganics:** | | | VMP1–6 |
| Iron | SW7380 | (mg/kg dry wt.) | 11,400 |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | <45 |
| pH | SW9045 | (units) | 7.5 |
| TKN | E351.2 | (mg/kg dry wt.) | 44 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 260 |
| **Soil Physical Parameters:** | | | VMP1–6 |
| Moisture Content | ASTM D2216 | (% by wt.) | 12 |
| Gravel | ASTM D422 | (% by wt.) | 0.8 |
| Sand | ASTM D422 | (% by wt.) | 80.1 |
| Silt | ASTM D422 | (% by wt.) | 9.7 |
| Clay | ASTM D422 | (% by wt.) | 9.4 |

NOTES:

TRPH – Total recoverable petroleum hydrocarbons
TVH–jf – Total volatile hydrocarbons as jet fuel
TKN – Total Kjeldahl nitrogen
ppmv – Parts per million by volume

<5.0 – below given detection limit
NA – Not Analyzed
CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram

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were zero at the background well at all monitored depths, indicating that the location was acceptable for background well completion (see Table 1.11).

### 2.6.2 Soil Sample Laboratory Analysis

According to protocol procedures, one soil sample was collected for laboratory analysis using procedures described in Section 2.1.2. The soil sample was collected at VMP-1 from a depth of 28 feet bgs (see Table 1.11).

The soil sample selected for laboratory analysis was delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical analysis. The chain-of-custody form is included in Appendix C. The sample was then transferred to Sequoia Analytical in Redwood City, California for analysis of TKN to establish baseline soil nutrient conditions. The result of this analysis was 140 mg/kg TKN.

### 2.6.3 Soil-Gas Sample Results

According to protocol document procedures, no subsurface soil-gas samples were collected for laboratory analysis at the background well. However, soil-gas samples were collected for field measurements to determine whether a background *in situ* respiration (ISR) test was necessary.

Subsurface soil-gas samples were collected using procedures described in Section 2.1.3. The initial soil-gas chemistry measured at the background well is summarized in Table 2.6. Because some initial oxygen levels were below 18%, a background well respiration test is required according to protocol document procedures. An ISR test at the background well will be conducted during the scheduled six-month ISR test at the bioventing sites in order to perform any necessary corrections to oxygen-utilization rates. Although it cannot be assumed that no inorganic or natural carbon sources contributed to oxygen uptake during the ISR tests described in Section 3.0, the high oxygen readings from VMP-1 indicate that any oxygen uptake contributable to inorganic or natural carbon sources is probably minimal.

### 2.6.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.6.5 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to background well sampling were used with no significant exceptions.

## 2.7 Davis Global Communications Site (Davis Site)

### 2.7.1 Soil Sample Field Analysis

Contaminated soils were identified based on procedures described in Section 2.1.1. With a few exceptions, OVA readings using the PID were generally higher or of the same order of magnitude as those using the THVA (see Table 1.13). As expected, OVA readings at the Davis site were lower than those at the other McClellan sites because the

# Table 2.6
# INITIAL CONDITIONS
# Base Fire Department (Background Well)
# McClellan AFB, California

| Well No.– depth | SOIL GAS $O_2$ (%) | SOIL GAS $CO_2$ (%) | SOIL GAS TVH (ppmv) |
|---|---|---|---|
| VMP1–8 | 18.5 | 2.2 | 110 |
| VMP1–18 | 18.5 | 2.1 | 360 |
| VMP1–28 | 17.8 | 1.8 | 100 |
| VMP1–39.5 | 17.5 | 1.8 | 105 |

*NOTES*

1. All measurements by field instrumentation.
2. TVH: Total volatile hydrocarbons.

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fuel hydrocarbon contamination is primarily due to diesel fuel, which is less volatile than gasoline or jet fuel.

### 2.7.2 Soil Sample Laboratory Analysis

Soil samples were collected and selected for laboratory analysis using procedures described in Section 2.1.2. Samples were collected at VW-1, VMP-1, and VMP-2 from depths of 32.5, 15, and 50 feet bgs, respectively (see Table 1.13). Samples from the background well at the Davis site (VMP-4) were collected from a depth of 15 feet bgs.

Soil samples selected for laboratory analysis were delivered by Federal Express™ to PACE, Inc. in Novato, California for chemical and physical analysis. Chain-of-custody forms are included in Appendix C. With the exception of the background well, analytes for all soil samples were: TRPH; BTEX; purgeable halocarbons; iron; total alkalinity; pH; TKN; total phosphorus; moisture content; and grain size distribution. The background well soil sample was only analyzed for TKN in order to establish baseline nutrient conditions. Samples to be analyzed for TKN, total phosphorus, and grain size distribution were transferred to Sequoia Analytical in Redwood City, California. The results of all analyses for the Davis site samples are summarized in Table 2.7. The TRPH concentrations are also included on the geologic cross section (Figure 1.17).

### 2.7.3 Soil-Gas/Surface Air Sample Laboratory Analysis

Subsurface soil-gas samples were collected using procedures described in Section 2.1.3. Soil-gas samples were collected from the vent well (VW-1) and from the screened intervals at 37.5 and 45 feet bgs in VMP-1 and VMP-3, respectively. The soil-gas samples were analyzed for TVH-jf, BTEX, and chlorinated volatile organics (TVH-jf is the standard quantitation used by the laboratory for the low volatile components found in diesel fuel). Results of these analyses are summarized in Table 2.7.

Additional surface air samples were collected for laboratory analysis before and during the air injection to estimate potential emissions of TVH-jf, BTEX, and chlorinated volatile organics to the atmosphere resulting from air injection during the pilot test. Two samples were collected at a surface point (SPT) located 18 feet to the south of VW-1. One sample was collected prior to the start of air injection (sample SPT4A) and one sample 3 hours after the start of and during air injection (sample SPT4B). The results of these analyses are shown in Table 2.6 and discussed in Section 3.5.5.

### 2.7.4 Field QA/QC Results

No QA/QC soil or soil-gas samples (field duplicates) were collected during sampling activities at the test site.

### 2.7.5 Subsurface Contamination

Although the horizontal extent of the hydrocarbon contamination at the site remains unknown, all boreholes drilled to groundwater at approximately 55 feet bgs encountered evidence of hydrocarbon contamination at the capillary fringe and in the smear zone created by seasonal groundwater fluctuations. Although no groundwater samples were

# TABLE 2.7
# SOIL, SOIL–GAS, and SURFACE AIR ANALYTICAL RESULTS
## Davis Site
## McClellan AFB, California

SAMPLE LOCATION – DEPTH (WELL NUMBER AND FEET BELOW GROUND SURFACE)

**Soil Contaminants:**

| ANALYTE | METHOD | UNITS | VW1–32.5 | VMP1–15 | VMP2–50 |
|---|---|---|---|---|---|
| TRPH | E418.1 | (mg/kg) | 15,500 | 1,370 | 1,210 |
| Benzene | SW8020 | (mg/kg) | <0.4 | <0.2 | <0.2 |
| Toluene | SW8020 | (mg/kg) | <0.4 | <0.2 | <0.2 |
| Ethylbenzene | SW8020 | (mg/kg) | <0.4 | <0.2 | <0.2 |
| Xylenes, Total | SW8020 | (mg/kg) | <0.7 | <0.4 | <0.4 |
| Purgeable Halocarbons | SW8010 | (mg/kg) | all ND | all ND | all ND |

**Soil Inorganics:**

| ANALYTE | METHOD | UNITS | VW1–32.5 | VMP1–15 | VMP2–50 | VMP4–15 |
|---|---|---|---|---|---|---|
| Iron | SW7380 | (mg/kg dry wt.) | 36,100 | 32,900 | 51,500 | NA |
| Total Alkalinity | SM403 | (mg/kg as CaCO3) | <48 | 270 | 750 | NA |
| pH | SW9045 | (units) | 7.4 | 7.8 | 8.7 | NA |
| TKN | E351.2 | (mg/kg dry wt.) | 71 | 480 | 320 | 160 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 370 | 330 | 500 | NA |

**Soil Physical Parameters:**

| ANALYTE | METHOD | UNITS | VW1–32.5 | VMP1–15 | VMP2–50 |
|---|---|---|---|---|---|
| Moisture Content | ASTM D2216 | (% by wt.) | 17 | 18 | 20 |
| Gravel | ASTM D422 | (% by wt.) | 0.2 | 2.1 | 0.0 |
| Sand | ASTM D422 | (% by wt.) | 81.8 | 32.5 | 0.8 |
| Silt | ASTM D422 | (% by wt.) | 12.8 | 44.6 | 61.1 |
| Clay | ASTM D422 | (% by wt.) | 5.3 | 20.8 | 38.0 |

**Soil–Gas/Surface Air Hydrocarbons:**

| ANALYTE | METHOD | UNITS | VW1 | VMP1–37.5 | VMP3–45 | SPT4A (a) | SPT4B (b) |
|---|---|---|---|---|---|---|---|
| TVH–jf | EPA TO–3 | (ppmv) | 84 | 380 | 270 | 1.2 | 1.3 |
| Benzene | EPA TO–3 | (ppmv) | 0.005 | <0.011 | <0.011 | <0.002 | <0.004 |
| Toluene | EPA TO–3 | (ppmv) | <0.002 | <0.011 | <0.011 | <0.002 | <0.004 |
| Ethylbenzene (c) | EPA TO–3 | (ppmv) | 0.013 | 0.55 | 0.62 | 0.004 | <0.004 |
| Xylenes, Total (c) | EPA TO–3 | (ppmv) | 0.029 | 1.1 | 0.88 | 0.008 | 0.004 |

**Soil–Gas/Surface Air Contaminants:**

| ANALYTE | METHOD | UNITS | VW1 | VMP1–37.5 | VMP3–45 | SPT4A (a) | SPT4B (b) |
|---|---|---|---|---|---|---|---|
| 1,2–dichloroethane | EPA TO–14 | (ppmv) | <0.0042 | <0.0043 | 0.017 | <0.0044 | <0.009 |
| Benzene | EPA TO–14 | (ppmv) | 0.0067 | <0.0043 | <0.011 | <0.0044 | <0.009 |
| cis–1,2–dichloroethene | EPA TO–14 | (ppmv) | <0.0042 | 0.0091 | <0.011 | <0.0044 | <0.009 |
| Ethylbenzene | EPA TO–14 | (ppmv) | 0.0072 | 0.011 | <0.011 | <0.0044 | <0.009 |
| Freon 113 | EPA TO–14 | (ppmv) | 0.022 | 0.860 | 0.035 | <0.0044 | <0.009 |
| Freon 12 | EPA TO–14 | (ppmv) | <0.0042 | 0.094 | <0.011 | <0.0044 | <0.009 |
| Methylene chloride | EPA TO–14 | (ppmv) | <0.0042 | <0.0043 | <0.011 | 0.032 | 0.020 |
| TCE | EPA TO–14 | (ppmv) | <0.0042 | 0.015 | <0.011 | <0.0044 | <0.009 |
| Toluene | EPA TO–14 | (ppmv) | <0.0042 | 0.013 | <0.011 | 0.0064 | 0.018 |
| Trimethylbenzenes | EPA TO–14 | (ppmv) | 0.0247 | 0.023 | <0.011 | <0.0044 | <0.009 |
| Vinyl chloride | EPA TO–14 | (ppmv) | 0.0051 | <0.0043 | <0.011 | <0.0044 | <0.009 |
| Xylenes, Total | EPA TO–14 | (ppmv) | 0.031 | 0.052 | 0.013 | <0.0044 | 0.0096 |

NOTES:

TRPH – Total recoverable petroleum hydrocarbons
TVH–jf – Total volatile hydrocarbons as jet fuel
TKN – Total Kjeldahl nitrogen
(a) collected prior to air injection
(b) collected during air injection
(c) Biased high due to coelution based on TO–14 analysis

$\boxed{<5.0}$ – below given detection limit
NA – Not Analyzed
ND – Not Detected
CaCO3 – Calcium carbonate
mg/kg – milligrams per kilogram
ppmv – Parts per million by volume

02/02/94
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collected as part of this investigation, groundwater contamination has been documented by previous investigations. OVA readings greater than 100 ppmv were measured in all boreholes except for borehole number 2 (abandoned).

OVA readings were relatively high in VW-1 and VMP-1 from below the base of fill to groundwater at approximately 55 feet bgs. In VMP-2 and VMP-3, the highest OVA readings were generally recorded from approximately 45 feet bgs to groundwater, suggesting that seasonal groundwater fluctuations may be primarily responsible for the contamination at those points and that the main source of contamination is closer to VW-1 and VMP-1. Blue and/or blue-green discoloration and fuel odors were noted in all boreholes that penetrated native soils beneath the fill at the tank site. At the background well, no contamination was observed in the physical features of the soil or determined based on the OVA readings.

Laboratory analysis of soil and soil-gas samples documented hydrocarbon contamination in all wells at the tank site. The maximum contaminant level in soil was 15,500 mg/kg TRPH at VW-1. Benzene, other BTEX components, and purgeable halocarbons were not detected in any soil samples. Due to the non-volatile nature of diesel fuel contamination, only low levels of fuel hydrocarbon contaminants were detected in subsurface soil-gas samples, as expected. Benzene was only detected in one soil-gas sample at 0.0067 ppmv (at VW-1). The maximum level of TVH-jf was 380 ppmv (at VMP1-37.5).

Results from the chlorinated organic analysis of soil-gas samples showed very low levels of contaminants. TCE was detected in only one sample at 0.015 ppmv (at VMP1-37.5), vinyl chloride was detected in only one sample at 0.0051 ppmv (at VW-1), and PCE was not detected in any samples.

### 2.7.6 Exceptions To Protocol Document Procedures

Procedures described in the protocol document related to soil and soil-gas sampling were used with the following exceptions:

- Soil samples were screened in the field (OVA readings) using both a THVA and a PID in order to compare data from both devices.
- Because previous investigations at the site have documented contamination from chlorinated organics, soil samples were analyzed using EPA 8010 in addition to the standard TRPH and BTEX analyses. For the same reason, soil-gas samples were analyzed using EPA TO-14 in addition to the standard EPA TO-3 analysis.
- Surface air samples were collected before and during the air injection and analyzed for TVH-jf, BTEX, and chlorinated organics. This sampling was performed at the request of McClellan AFB and SMAQMD to evaluate potential atmospheric emissions during the pilot test.

# 3.0 PILOT TEST RESULTS AND RECOMMENDATIONS

## 3.1 Tank Farm #2 (TF-2)

### 3.1.1 Initial Soil-Gas Chemistry

Prior to initiating air injection, the VW and all VMPs were purged until oxygen levels had stabilized, and then initial oxygen and carbon dioxide concentrations were sampled using portable gas analyzers as described in the protocol document (Hinchee et. al. 1992). Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at the VW and at all VMP screened intervals, indicating soil contamination and natural biological activity at 10 to 35 feet bgs. The initial soil-gas chemistry measured at TF-2 is summarized in Table 3.1. TVH for soil-gas samples (both field instrument measurements and laboratory analytical results) and TRPH and BTEX concentrations for soil samples are also provided to demonstrate the relationship between oxygen levels and the contaminated soils. Initial oxygen levels are also shown on the geologic cross-section for the site (Figure 1.2).

### 3.1.2 Air Permeability

An air permeability (AP) test was conducted on 27 July 1993 according to protocol document procedures. Air was injected into VW-1 for approximately 5 hours at a rate of 30 standard cubic feet per minute (scfm) with an average pressure at the well-head of 100 inches of water (in. $H_2O$). The dynamic pressure responses at the VMPs are shown on Figures D.1 through D.3 (see Appendix D).

Due to the relatively slow pressure response and the length of time required to achieve steady-state conditions, the dynamic response method was used to calculate air permeability values, as detailed in the protocol document. Calculated air permeabilities for each VMP and depth are shown on Figures D.1 through D.3. Permeability values ranged from 6.4 to 35 darcys, typical for the silty clays and sandy clays which predominate at the site. Significant pressure response was noted at all VMPs and at all depths. The permeability values indicate that the site soils are sufficiently permeable to air for the bioventing technology.

### 3.1.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.2 presents the change in soil-gas oxygen levels during the AP test and after approximately one month of air injection. During the AP test, increases in soil-gas oxygen levels occurred at all screened depths in VMP-1, indicating successful oxygen transport at a radial distance of at least 15 ft, even for the relatively brief injection period. At all the screened depths in VMP-2 and the 32-foot screen in VMP-3, oxygen levels appeared to decrease during the initial AP test possibly due to displacement of oxygen-

# Table 3.1
# INITIAL CONDITIONS
# Tank Farm #2
# McClellan AFB, California

| Well No.– depth | SOIL GAS O$_2$ (%) | CO$_2$ (%) | TVH–jf (ppmv) | TVH (ppmv) | SOIL TRPH (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| VW1–(10 – 35) | 7.0 | 4.2 | 31,000 | >10,000 | 100 | ND | 0.027 | 0.013 | 0.11 |
| VMP1–15 | 11.8 | 1.3 | | 7,700 | | | | | |
| VMP1–20 | 8.5 | 3.5 | 23,000 | >10,000 | ND | 0.004 | 0.28 | 0.054 | 0.2 |
| VMP1–28 | 5.3 | 4.3 | | >10,000 | | | | | |
| VMP2–15 | 8.0 | 2.8 | | >10,000 | | | | | |
| VMP2–21 | 7.0 | 4.0 | | >10,000 | ND | ND | 4.4 | 0.29 | 1.4 |
| VMP2–35 | 6.8 | 2.0 | | >10,000 | | | | | |
| VMP3–13 | 2.0 | 3.0 | 34,000 | >10,000 | | | | | |
| VMP3–20 | 1.5 | 4.5 | | >10,000 | | | | | |
| VMP3–32 | 11.0 | 2.5 | | >10,000 | | | | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)
TVH : Total Volatile Hydrocarbons (THVA field instrument)
ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. $O_2/CO_2$ measurements by field instrumentation.
2. Soil sample at VW–1 taken at a depth of 22.5 feet bgs. tf2tab31
3. Benzene, Toluene, Ethylbenzene, and Total xylenes by EPA Method 8020. 01/26/94

## Table 3.2
## INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
## Tank Farm #2
## McClellan AFB, California

| Well No.– depth | Distance from VW–1 (ft) | Air Permeability Test Inital $O_2$ (%) | Air Permeability Test Final $O_2$ (%) | Long–term $O_2$ Response (%) |
|---|---|---|---|---|
| VMP1–15 | 15 | 11.8 | 15.0 | 19.1 |
| VMP1–20 | 15 | 8.5 | 17.5 | 20.8 |
| VMP1–28 | 15 | 5.3 | 15.5 | 20.5 |
| VMP2–15 | 30 | 8.0 | 1.5 | 6.0 |
| VMP2–21 | 30 | 7.0 | 2.5 | 19.5 |
| VMP2–35 | 30 | 6.8 | 4.5 | 20.0 |
| VMP3–13 | 50 | 2.0 | 1.5 | 1.0 |
| VMP3–20 | 50 | 1.5 | 1.0 | 1.5 |
| VMP3–32 | 50 | 11.0 | 2.8 | 18.0 |

*LEGEND*

(shaded) : Sample was not taken/analyzed.

Air Permeability Test lasting 5.3 hours performed on 27 Jul 1993

Long–term $O_2$ measurements taken on 31 Aug 1993

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depleted soil-gas. Therefore, although short-term oxygen increases were not noted at these points, long-term oxygen increases were expected as oxygen-depleted soil-gas would eventually be replaced with fresh air.

The measurements taken after one month of air injection confirmed that long-term oxygen response occurred at these points as expected. However, no oxygen response was noted at the two shallower points in VMP-3 after one month of air injection. These points may be beyond the radius of influence of the injection well; however, long-term aeration of these points due to diffusion of oxygen through soil may be expected and will be monitored after approximately 6 months and 1 year of air injection.

Based on measurable pressure response, which is an indicator of long-term oxygen transport, and the change in oxygen levels at one-month into the injection period, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 50 feet from VW-1. The radius of oxygen influence at the site may vary with depth because of the differing soil type and soil permeabilities. The effective treatment radius will be better defined by monitoring the oxygen and contaminated soil-gas levels during the extended (one-year) pilot test at the site.

### 3.1.4 *In Situ* Respiration Rates

An *in situ* respiration (ISR) test was conducted at TF-2 between 28 and 30 July 1993 according to protocol document procedures. Air (20.8 percent oxygen) was injected at a rate of approximately 1 scfm into four VMP screened intervals (VMP1-20, VMP2-21, VMP3-13, and VMP3-20) for 23.5 hours in order to oxygenate surrounding soils. After air injection was ceased, oxygen, carbon dioxide, and TVH levels in all VMP screened intervals (including those without air injection) were measured in soil gas for the following 24 hours. The results of the ISR test for eight of the nine points at TF-2 are presented on Figures E.1 to E.8 (see Appendix E).

Results from the ISR test indicate that all of the VMP screened intervals had hydrocarbon contamination and active microorganism populations. The oxygen-utilization rates measured at the site were moderate, ranging from approximately 0.10% per hour at the shallower depths in VMP-1 to approximately 0.47% per hour at VMP3-13. An oxygen-utilization rate was not calculated at VMP3-32 because the high initial oxygen level indicated little biological activity in those soils.

The air injected into the VMPs during the ISR test was a 3-percent helium mixture in air. The helium is used both as a tracer gas and to evaluate the effectiveness of the bentonite seals in the VW and VMPs. No appreciable loss of helium occurred at any VMPs where helium was injected between the end of injection and the final ISR readings taken after 24 hours of monitoring. Therefore, most of the oxygen loss observed during the ISR test was a result of bacterial respiration and not a result of either faulty well construction or overpurging of the VMPs during sampling.

Helium was also monitored at VW-1 and at VMPs where air injection did not occur. Detection of helium at these points provides some evidence that significant volumes of soil were aerated by the 1 scfm pumps and consistent helium levels at these points over time indicates that decreasing oxygen levels in extracted soil-gas are due to respiration.

Based on the measured oxygen-utilization rates and the laboratory analyses presented in Section 2.1, an estimated 180 to 910 mg of fuel per kg of soil can be biodegraded each year at this site. The lower estimate reflects the slow oxygen-utilization rate measured at VMP1-20, while the higher estimate reflects the highest oxygen-utilization rate that was measured at VMP1-28 and VMP3-20. Although biodegradation rates are also highly dependent on moisture content (which affects air-filled porosity), lab analytical results of moisture contents in soil samples collected from the VMP-1 and VMP-2 boreholes appeared to be consistent. The locations with the higher biodegradation rate estimates generally correlated to the locations with lower initial oxygen levels and high TVH levels in soil gas (prior to the AP test). The biodegradation rate estimates are based on calculated air-filled porosities and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Methods of calculation followed the procedures in the protocol document and are detailed in Appendix F.

Additional respiration testing at 6 months and one year following installation of the extended (one-year) pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.3 summarizes the data from the initial pilot test at TF-2.

### 3.1.5 Potential Air Emissions

Air samples were taken at the ground surface at TF-2 before and during air injection in order to evaluate the potential for discharge of hydrocarbons to the atmosphere resulting from subsurface air injection. The results indicate that no significant increase in TVH or BTEX levels above those found prior to air injection at the site are expected to occur during the extended (one-year) pilot test.

Nine surface measurement points were located radially around the injection well (VW-1) and at distances expected to be under the influence of air injection. The surface points were arranged around VW-1 radiating outward in three arms of three points each, spaced roughly 120 degrees apart. The points in each arm were spaced at 16, 32, and 48 feet from VW-1. Samples were collected using an isolation flux chamber and followed protocols established by the Environmental Protection Agency's Environmental Monitoring Systems Laboratory (USEPA, February 1986). Hydrocarbon concentrations were measured using both the THVA and laboratory analysis.

Results from the THVA were recorded in the field notebook and are shown in Table 3.4. Although the level measured with the THVA at SPT7 after 5 hours of air injection was higher than expected, the result from the laboratory analysis at SPT7 did not confirm the THVA result (see Table 2.1). Therefore, the higher measurement from the THVA is thought to be due to the difficulty of measuring low concentrations with the THVA.

In order to determine the TVH-jf and BTEX content of potential emissions, two surface air samples were collected for laboratory analysis, one prior to air injection and one during air injection (5 hours after initiation of injection) at the same location (SPT7). The samples were collected in 1-liter Summa® cannisters immediately after the appropriate residence time was reached for the flux chamber (24 minutes) and shipped following procedures outlined in Section 2.1.3. Results of the laboratory analysis for the

# Table 3.3
# PILOT TEST DATA SUMMARY
## Tank Farm #2
## McClellan AFB, California

| | Soil and Soil Gas Data | | | Air Permeability Test | | | | In Situ Respiration Test | | | | | Calculated Biodegradation Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Type | Laboratory Analytical Results | | Initial Soil Gas | | Final Soil Gas | Air Perm. | Initial Soil Gas | | Final Soil Gas | | $O_2$ Util. Rate | |
| WELL No.–DEPTH | | TRPH (mg/kg) | TVH–jf (ppmv) | $O_2$ (%) | $CO_2$ (%) | $O_2$ (%) | k (darcy) | $O_2$ (%) | He (%) | $O_2$ (%) | He (%) | $k_o$ (%/hr) | $K_b$ (mg fuel/kg soil per yr) |
| VW1–(10 – 35) | sandy CLAY/clayey SAND | 100 | 31,000 | 7.0 | 4.2 | | | 19.0 | 0.08 | 21.0 | 0.0 | | |
| VMP1–15 | fill: silty CLAY | | | 11.8 | 1.3 | 15.0 | 10 | 20.5 | 1.8 (a) | 17.8 | 1.1 | 0.11 | 230 |
| VMP1–20 • | clayey SAND/silty CLAY | ND | 23,000 | 8.5 | 3.5 | 17.5 | 6.4 | 20.5 | 2.1 (a) | 18.0 | 2.0 | 0.10 | 180 |
| VMP1–28 | clayey SAND | | | 5.3 | 4.3 | 15.5 | 9.4 | 16.8 | 2.0 (a) | 6.0 | 1.7 | 0.44 | 910 |
| VMP2–15 | silty CLAY | | | 8.0 | 2.8 | 1.5 | 16 | 19.5 | 1.2 (a) | 10.0 | 2.0 | 0.26 | 540 |
| VMP2–21 • | silty CLAY | ND | | 7.0 | 4.0 | 2.5 | 15 | 20.5 | 2.1 (a) | 11.0 | 1.7 | 0.28 | 580 |
| VMP2–35 | clayey, fine SAND | | | 6.8 | 2.0 | 4.5 | 15 | 17.5 | 1.4 (a) | 12.0 | 0.88 | 0.39 | 800 |
| VMP3–13 • | clayey SILT/fine SAND | | 34,000 | 2.0 | 3.0 | 1.5 | 16 | 19.5 | 2.2 (a) | 4.5 | 2.5 | 0.47 | 590 |
| VMP3–20 • | silty CLAY | | | 1.5 | 4.5 | 1.0 | 19 | 20.0 | 2.3 (a) | 5.5 | 2.5 | 0.44 | 910 |
| VMP3–32 | sandy CLAY | | | 11.0 | 2.5 | 2.8 | 35 | 3.0 | 0.12 | 0.0 | 0.13 | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)
• : VMP used for air injection during ISR test
(a) : He percentage is reported from the second set of readings. Equipment problems occurred during the first set of readings.

ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. VW–1 soil sample collected from 22.5 ft bgs.
2. Air Permeability Test conducted for 5.3 hrs at air injection rate of 30 scfm.
3. *In Situ* Respiration Test: air injection at selected VMPs for 23.5 hrs at 1.1 scfm; $O_2/CO_2$/TVH measurements taken for 24 hrs following injection.
4. Soil Temperature: 70.1 °F at VMP2–15; 69.8 °F at VMP2–35.

tf2tab33
01/26/94

# Table 3.4
# SURFACE AIR EMISSIONS
# Tank Farm #2
# McClellan AFB, California

| Location | Distance from VW–1 (ft) | Prior to Air Injection | During Air Injection (a) |
|---|---|---|---|
| | | TVH concentrations in ppmv | |
| SPT1 | 16 | 0 | 0 |
| SPT2 | 32 | 0 | 4 |
| SPT3 | 48 | 4 | 0 |
| SPT4 | 16 | 0 | 5 |
| SPT5 | 32 | 12 | 0 |
| SPT6 | 48 | 3 | 0 |
| SPT7 | 16 | 1.5 | 38 |
| SPT8 | 32 | 0 | 0 |
| SPT9 | 48 | 0 | 0 |

*LEGEND*

TVH : Total Volatile Hydrocarbons (THVA field instrument)
ppmv : parts per million by volume
(a) : Sample collection begun approximately 5 hrs after start of injection

tf2tab34
08/16/93

two samples were summarized in Table 2.1. During the AP test, the air injection flow rate was approximately 30 scfm and the estimated radius of influence was approximately 50 feet. Because neither TVH-jf nor benzene concentrations increased during air injection above the background level measured prior to air injection, potential emissions due to air injection are expected to be negligible at the site.

The long-term potential for air emissions during the extended (one-year) pilot test is also very low since the initial air injection probably displaced the highest concentrations of volatile organics from the soil and the concentrations typically decrease with continued air injection. In addition, any accumulated hydrocarbon vapors in the pore space will be biodegraded as they move horizontally through the soil.

### 3.1.6 Recommendations

Initial bioventing tests at TF-2 indicate that oxygen has been depleted in the contaminated soils and air injection is an effective method of increasing aerobic biodegradation of fuel contamination in the soil. The Air Force Center for Environmental Excellence (AFCEE) has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A small, 1.0-horsepower (HP) Gast™ regenerative blower (model R4) has been installed at TF-2 to continue a rate of air injection of approximately 50 scfm. In March 1994, ES personnel will return to the site to conduct a second respiration test. In September 1994, a final respiration test will be conducted and soil and soil-gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and VMPs.

## 3.2 Tank Farm #4 (TF-4)

### 3.2.1 Initial Soil-Gas Chemistry

Prior to initiating air injection, the VW and all VMPs were sampled using procedures described in Section 3.1.1. Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at the VW and at all VMP screened intervals, indicating soil contamination and natural biological activity at 10 to 25 feet bgs. The initial soil-gas chemistry measured at TF-4 is summarized in Table 3.5. TVH for soil-gas samples (both field instrument measurements and laboratory analytical results) and TPH-g and BTEX concentrations for soil samples are also provided to demonstrate the relationship between

# Table 3.5
# INITIAL CONDITIONS
# Tank Farm #4
# McClellan AFB, California

| Well No.– depth | SOIL GAS | | | | SOIL | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $O_2$ (%) | $CO_2$ (%) | TVH–g (ppmv) | TVH (ppmv) | TPH–g (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) |
| VW1–(10 – 25) | 5.0 | 8.0 | 1,900 | 1,500 | 46 | ND | ND | ND | 2.7 |
| VMP1–10 | 2.5 | 11.0 | | 1,000 | | | | | |
| VMP1–17.5 | 2.2 | 9.4 | 5,200 | 4,400 | 76 | ND | 0.062 | ND | 0.47 |
| VMP1–25 | 2.2 | 9.8 | | 1,600 | | | | | |
| VMP2–10 | 1.0 | 17.0 | | 1,400 | | | | | |
| VMP2–20 | 1.8 | 10.0 | | 260 | ND | ND | ND | ND | ND |
| VMP2–25 | 5.6 | 7.2 | | 88 | | | | | |
| VMP3–10 | 9.2 | 5.8 | | 32 | | | | | |
| VMP3–20 | 6.6 | 7.6 | 10 | 20 | | | | | |
| VMP3–25 | 9.0 | 6.4 | | ND | | | | | |

*LEGEND*

: Sample was not taken/analyzed.
TPH–g : Total Petroleum Hydrocarbons as gasoline (mod. EPA 8015)
TVH–g : Total Volatile Hydrocarbons as gasoline (EPA TO–3)
TVH : Total Volatile Hydrocarbons (THVA field instrument)
ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. $O_2/CO_2$ measurements by field instrumentation.
2. Soil samples taken at depths of 12.5 feet bgs, VW–1; 17.5 feet bgs, VMP–1; and 20 feet bgs, VMP–2.
3. Benzene, Toluene, Ethylbenzene, and Total Xylenes by EPA Method 8020.

tf4tab35
01/26/94

depleted oxygen levels and the contaminated soils. Initial oxygen levels are also shown on the geologic cross-section for the site (Figure 1.7).

### 3.2.2 Air Permeability

An AP test was conducted on 3 August 1993 according to protocol document procedures. Air was injected into VW-1 for approximately 7 hours at a rate of 17 scfm with an average pressure at the well-head of 133 in. $H_2O$. The dynamic pressure responses at the VMPs are shown on Figures D.4 through D.6 (see Appendix D).

Due to the relatively slow pressure response and the length of time required to achieve steady-state conditions, the dynamic response method was used to calculate air permeability values, as detailed in the protocol document. Calculated air permeabilities for each VMP and depth are shown on Figures D.4 through D.6. Permeability values ranged from 25 to 56 darcys, typical for the sandy silts and silty sands which predominate at the site (the change in the linear nature of the pressure response curve at VMP-1 and VMP-2 was due to an inadvertent decrease in the injection flow rate during the first 8 minutes of the test; permeability values have been calculated based on data after 8 minutes, when the flow rate was constant). With the exception of VMP2-10, significant pressure response (greater than 1.0 in $H_2O$) was noted at all VMPs and at all depths. The lower pressure response at VMP2-10 is likely due to the presence of fill material at this point, which can provide preferential air flow paths. The permeability values indicate that the site soils are sufficiently permeable to air for the bioventing technology.

### 3.2.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.6 presents the change in soil-gas oxygen levels during the AP test and after approximately two weeks of air injection. During the AP test, increases in soil-gas oxygen levels occurred at all measured screened depths, indicating successful oxygen transport at a radial distance of at least 30 feet, even for the relatively brief injection period.

The measurements taken after two weeks of air injection confirmed that long-term oxygen response occurred at these points as expected. However, no oxygen response was noted at VMP2-10. This same location also showed the smallest pressure response during the AP test, as discussed in sections 3.2.2. Long-term aeration of this point due to diffusion of oxygen through the soil may be expected and will be monitored after approximately six months and one year of air injection.

Based on measurable pressure response, which is an indicator of long-term oxygen transport, and the change in oxygen levels at two weeks into the injection period, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 30 feet from VW-1. The effective treatment radius will be better

# Table 3.6
# INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
# Tank Farm #4
# McClellan AFB, California

| Well No.– depth | Distance from VW–1 (ft) | Air Permeability Test: Inital $O_2$ (%) | Air Permeability Test: Final $O_2$ (%) | Long–term $O_2$ Response (%) |
|---|---|---|---|---|
| VMP1–10 | 15 | 2.5 | 11.8 | 15.0 |
| VMP1–17.5 | 15 | 2.2 | 18.8 | 18.5 |
| VMP1–25 | 15 | 2.2 | 18.0 | 19.0 |
| VMP2–10 | 15 | 1.0 | | 0.0 |
| VMP2–20 | 15 | 1.8 | 5.5 | 15.0 |
| VMP2–25 | 15 | 5.6 | 15.6 | 18.5 |
| VMP3–10 | 30 | 9.2 | | 14.0 |
| VMP3–20 | 30 | 6.6 | 8.0 | 15.8 |
| VMP3–25 | 30 | 9.0 | 11.8 | 15.5 |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
Air Permeability Test lasting 7.5 hours was performed on 3 Aug 1993
Long–term $O_2$ measurements taken on 9 Sep 1993

tf4tab36
01/06/94

defined by monitoring the oxygen and contaminated soil-gas levels during the extended (one-year) pilot test at the site.

### 3.2.4 *In Situ* Respiration Rates

An ISR test was conducted at TF-4 between 4 and 6 August 1993, according to protocol document procedures. Air (20.8 percent oxygen) was injected at a rate of approximately 1 scfm into 4 VMP screened intervals (VMP1-17.5, VMP1-25, VMP2-10, and VMP2-20) for 22 hours in order to oxygenate surrounding soils. No injection was performed at VMP-3, because the screened intervals were the least oxygen-depleted based on initial sampling measurements. After air injection was ceased, oxygen, carbon dioxide, and TVH levels in all VMP screen intervals (including those without air injection) were measured in soil gas for the following 28 hours. The results of the ISR test at TF-4 for seven of the nine points are presented on Figures E.9 to E.15 (see Appendix E).

Results from the ISR test indicate that the shallowest screened intervals (at approximately 10 and 20 feet bgs) had hydrocarbon contamination and active microorganism populations. Although no air was injected at VMP3-10, soils appeared to be sufficiently oxygenated by the previous AP test so that an oxygen-utilization rate could be calculated. The deeper screened intervals at 25 feet generally showed slower respiration rates. With the exception of VMP1-25 and VMP2-25, oxygen-utilization rates measured at the site were moderate, ranging from approximately 0.13% per hour at VMP2-20 to approximately 0.88% per hour at VMP3-10. The oxygen-utilization rates measured at VMP1-25 and VMP2-25 were slow, 0.056 and 0.019% per hour, respectively. Oxygen-utilization rates at the remaining VMPs were not calculated because the oxygen level measured at the start of the ISR test was not significantly different than that measured initially (prior to the AP test).

The air injected into the VMPs during the ISR test was, on average, a 3-percent helium mixture in air. The helium is used both as a tracer gas and to evaluate the effectiveness of the bentonite seals in the VW and VMPs. No appreciable loss of helium occurred at any VMPs where helium was injected between the end of injection and the final ISR readings taken after 28 hours of monitoring. Therefore, most of the oxygen loss observed during the ISR test was a result of bacterial respiration and not a result of either faulty well construction or overpurging of the VMPs during sampling.

Helium was also monitored at VW-1 and at VMPs where air injection did not occur. Detection of helium at these points provides some evidence that significant volumes of soil were aerated by the 1 scfm pumps and consistent helium levels at these points over time indicates that decreasing oxygen levels in extracted soil-gas are due to respiration.

Based on the measured oxygen-utilization rates and the laboratory analyses presented in Section 2.2, an estimated 30 to 840 mg of fuel per kg of soil can be biodegraded each year at this site. The lower estimate reflects the slow oxygen-utilization rate measured at VMP2-25. The higher estimate reflects the highest oxygen-utilization rate that was measured at VMP3-10. Except for VMP 3-10, the locations with higher biodegradation rate estimates generally correlated to the locations with lower initial oxygen levels (prior

to the AP test) or higher contamination levels in soil and soil gas. The biodegradation rate estimates are based on calculated air-filled porosities and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Methods of calculation followed the procedures in the protocol document and are detailed in Appendix F.

Additional respiration testing at 6 months and one year following installation of the extended (one-year) pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.7 summarizes the data from the initial pilot test at TF-4.

### 3.2.5 Recommendations

Initial bioventing tests at TF-4 indicate that oxygen has been depleted in the contaminated soils and air injection is an effective method of increasing aerobic biodegradation of fuel contamination in the soil. AFCEE has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A small, 1.0-HP Gast™ regenerative blower (model R4) has been installed at TF-4 to continue a rate of air injection of approximately 25 scfm. In March 1994, ES personnel will return to the site to conduct a second respiration test. In September 1994, a final respiration test will be conducted and soil and soil-gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and VMPs.

## 3.3 SA 6

### 3.3.1 Initial Soil-Gas Chemistry

Prior to initiating air injection, the VW and all VMPs were sampled using procedures described in Section 3.1.1. Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at VW-18 and at all VMP screened intervals, indicating soil contamination and natural biological activity at 15 to 100 feet bgs. At VW-19, TVH levels were lower and the oxygen level was not as depleted, possibly due to the somewhat lower contaminant levels found there during downhole soil-gas sampling (see Table 2.3b) and/or the length of the screened interval (85 feet), which likely spans zones with only slight soil contamination and higher $0_2$concentrations. The initial soil-gas chemistry measured at SA 6 is summarized in Table 3.8. TVH for soil-gas samples (both field instrument measurements and laboratory analytical results) and TPH-g and BTEX

# Table 3.7
# PILOT TEST DATA SUMMARY
## Tank Farm #4
## McClellan AFB, California

| | Soil and Soil Gas Data | | | Air Permeability Test | | | | *In Situ* Respiration Test | | | | | Calculated Biodegradation Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Type | Laboratory Analytical Results | | Initial Soil Gas | | Final Soil Gas | Air Perm. | Initial Soil Gas | | Final Soil Gas | | $O_2$ Util. Rate | |
| WELL No.–DEPTH | | TPH–g (mg/kg) | TVH–g (ppmv) | $O_2$ (%) | $CO_2$ (%) | $O_2$ (%) | k (darcy) | $O_2$ (%) | He (%) | $O_2$ (%) | He (%) | $k_o$ (%/hr) | $K_b$ (mg fuel/kg soil per yr) |
| VW1–(10 – 25) | | 46 | 1,900 | 5.0 | 8.0 | | | 11.2 | 1.8 | 14.8 | 1.8 | | |
| VMP1–10 | fill: silty SAND | | | 2.5 | 11.0 | 11.8 | 25 | 19.0 | 3.1 | 11.6 | 2.8 | 0.27 | 260 |
| VMP1–17.5 • | clayey, silty SAND | 76 | 5,200 | 2.2 | 9.4 | 18.8 | 26 | 20.0 | 3.7 | 12.4 | 3.6 | 0.28 | 840 |
| VMP1–25 • | clayey, silty SAND | | | 2.2 | 9.8 | 18.0 | 26 | 20.2 | 3.6 | 18.8 | 3.0 | 0.056 | 100 |
| VMP2–10 • | fill: clayey, silty SAND | | | 1.0 | 17.0 | | 56 | 20.0 | 3.4 | 6.4 | 3.2 | 0.63 | 1,110 |
| VMP2–20 • | clayey,silty SAND | ND | | 1.8 | 10.0 | 5.5 | 29 | 20.2 | 3.4 | 16.4 | 2.9 | 0.13 | 40 |
| VMP2–25 | sandy, clayey SILT | | | 5.6 | 7.2 | 15.6 | 28 | 18.6 | 2.9 | 18.2 | 2.6 | 0.019 | 30 |
| VMP3–10 | silty SAND | | | 9.2 | 5.8 | | 30 | 18.0 | 0.0 | 6.0 | 0.0 | 0.88 | 840 |
| VMP3–20 | silty SAND | | 10 | 6.6 | 7.6 | 8.0 | 25 | 9.2 | 0.0 | 7.8 | 0.0 | | |
| VMP3–25 | sandy SILT | | | 9.0 | 6.4 | 11.8 | 27 | 9.8 | 0.13 | 13.4 | 0.19 | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
TPH–g : Total Petroleum Hydrocarbons as gasoline (mod. EPA 8015)
TVH–g : Total Volatile Hydrocarbons as gasoline (EPA TO–3)
• : VMP used for air injection during ISR test

ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. VW–1 soil sample collected from 12.5 ft. bgs.
2. Air Permeability Test conducted for 7.5 hrs at air injection rate of 17 scfm.
3. *In Situ* Respiration Test: air injection at selected VMPs for 22 hrs at 1.1 scfm; $O_2$/$CO_2$/TVH/He measurements taken for 28 hrs following injection.
4. Soil Temperature: 79.1 °F at VMP1–10; 68.7 °F at VMP1–25.

tf4tab37
01/26/94

# Table 3.8
# INITIAL CONDITIONS
# SA 6
# McClellan AFB, California

| Well No.– depth | SOIL GAS (a) $O_2$ (%) | $CO_2$ (%) | TVH–g (ppmv) | TVH (ppmv) | SOIL TPH–g (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| VW18–(25–100) | 1.0 | 12.0 | 14,000 | >10,000 | | | | | |
| VW19–(15–100) | 16.5 | 2.5 | 55 | 58 | | | | | |
| VMP1–17 | 1.2 | 15.2 | 130,000 | >10,000 | 1,210 | 4.2 | 18 | 14 | 27 |
| VMP1–30 | 1.0 | 12.2 | | 5,200 | | | | | |
| VMP1–54 | 10.5 | 5.5 | | 1,000 | | | | | |
| VMP2–19.5 | 1.2 | 20.0 | | >10,000 | | | | | |
| VMP2–30 | 2.2 | 12.0 | | >10,000 | | | | | |
| VMP2–49 | 3.0 | 9.2 | | 5,400 | | | | | |
| VPN20–24 | 1.5 | 10.0 | 13,000 | >10,000 | | | | | |
| VPN20–37 | 1.0 | 9.5 | | >10,000 | | | | | |
| VPN20–49 | 3.0 | 7.2 | | 3,400 | | | | | |
| VPN20–57 | 1.5 | 7.0 | | 900 | | | | | |
| VPN20–75 | 3.0 | 7.8 | | 73 | | | | | |
| VPN20–99 | 3.2 | 4.8 | | 75 | | | | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.

TPH–g : Total Petroleum Hydrocarbons as gasoline (mod. EPA 8015)

TVH–g : Total Volatile Hydrocarbons as gasoline (EPA TO–3)

TVH : Total Volatile Hydrocarbons (THVA field instrument)

(a) : Soil–gas measurements for VW–19 and VPN–20 taken on 7 July 1993; others taken on 30 August 1993

ND : not detected

mg/kg : milligrams per kilogram

ppmv : parts per million by volume

*NOTES*

1. $O_2/CO_2$ measurements by field instrumentation.
2. Benzene, Toluene, Ethylbenzene, and Total xylenes by EPA Method 8020.

sa6tab38

01/26/94

concentrations for soil samples are also provided to demonstrate the relationship between depleted oxygen levels and the contaminated soils. Initial oxygen levels are also shown on the geologic cross-section for the site (Figure 1.9).

### 3.3.2 Air Permeability

An AP test was conducted on 31 August 1993 according to protocol document procedures. Air was injected into VW-18 for approximately 9 hours at a rate of 38 scfm with an average pressure at the well-head of 28 in. $H_2O$. The dynamic pressure responses at the VMPs are shown on Figures D.7 through D.11 (see Appendix D).

Due to the relatively slow pressure response and the length of time required to achieve steady-state conditions, the dynamic response method was used to calculate air permeability values, as detailed in the protocol document. Calculated air permeabilities for VW-19 and each VMP depth are shown on Figures D.7 through D.11. Permeability values ranged from 7.3 to 24 darcys, typical for the silty and sandy soils which predominate at the site. Significant pressure response was noted at VW-19 and at all VMP depths. The permeability values indicate that the site soils are sufficiently permeable to air for the bioventing technology.

### 3.3.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.9 presents the change in soil-gas oxygen levels during the AP test and after approximately one week of air injection. During the AP test, increases in soil-gas oxygen levels occurred at all screened depths in VMP-1, indicating successful oxygen transport at a radial distance of at least 10 ft, even for the relatively brief injection period.

Results from other VMPs during the AP test were mixed: some depths showed significant oxygen increases (VPN20-49 and VPN20-57), while some depths showed no appreciable change. Although short-term oxygen increases were not noted at these points, pressure response, which is an indicator of potential for long-term oxygen transport, was measured at all points. As shown in Table 3.9, the measurements taken after one week of air injection confirmed that long-term oxygen response occurred at all points.

Based on measurable pressure response and the change in oxygen levels at one week into the injection period, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 30 feet from VW-18 and VW-19. The effective treatment radius will be better defined by monitoring the oxygen and contaminated soil-gas levels during the extended (one-year) pilot test at the site.

### 3.3.4 *In Situ* Respiration Rates

Two ISR tests were conducted at SA 6. The first ISR test evaluated respiration rates at VPN-20 and was conducted between 7 and 9 July 1993 prior to drilling activities and the AP test by ES at the site. The second ISR test evaluated respiration rates at VW-18,

# Table 3.9
# INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
# SA 6
# McClellan AFB, California

| Well No.– depth | Distance from VW–18 (ft) | Air Permeability Test: Inital $O_2$ (%) | Air Permeability Test: Final $O_2$ (%) | Long–term $O_2$ Response (%) |
|---|---|---|---|---|
| VW19–(15–100) | 23 | 16.5 | 19.0 | |
| VMP1–17 | 10 | 1.2 | 4.0 | 10.5 |
| VMP1–30 | 10 | 1.0 | 11.5 | 17.5 |
| VMP1–54 | 10 | 10.5 | 20.8 | 20.5 |
| VMP2–19.5 | 25 | 1.2 | 1.5 | 12.5 |
| VMP2–30 | 25 | 2.2 | 2.5 | 16.5 |
| VMP2–49 | 25 | 3.0 | 7.0 | 18.5 |
| VPN20–24 | 30 | 1.5 | 5.0 | 15.5 |
| VPN20–37 | 30 | 1.0 | 2.0 | 19.2 |
| VPN20–49 | 30 | 3.0 | 17.5 | 20.0 |
| VPN20–57 | 30 | 1.5 | 18.0 | 20.5 |
| VPN20–75 | 30 | 3.0 | 8.5 | 20.2 |
| VPN20–99 | 30 | 3.2 | 8.0 | 19.2 |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
Air Permeability Test lasting 9 hours performed on 31 Aug 1993
Long–term $O_2$ measurements taken on 9 Sep 1993

sa6tab39
01/26/94

VW-19, VMP-1, and VMP-2 and was conducted between 1 and 3 September 1993. During both ISR tests, air (20.8 percent oxygen) was injected at a rate of 1 scfm into selected VMP screened intervals for approximately 20 hours in order to oxygenate surrounding soils. During the first ISR test, air was injected at VPN20-24, VPN20-37, VPN20-57, and VPN20-75. During the second ISR test, air was injected at VMP1-17, VMP1-30, VMP2-19.5, and VMP2-49. After air injection was ceased, oxygen, carbon dioxide, and TVH levels in all VW and VMP screened intervals (including those without air injection) were measured in soil gas for the following 28 hours. The results of ISR tests for 11 of the 14 measured points at this site are presented on Figures E.16 to E.26 (see Appendix E).

Results from the ISR tests indicate both VWs and most VMPs had soil hydrocarbon contamination and active microorganism populations, although respiration rates generally appeared to decrease with depth. The screened intervals below approximately 50 feet bgs generally showed slower respiration rates. Unexpectedly, VW-19 showed a much faster oxygen-utilization rate than VW-18, where contamination appeared to be higher based on initial soil-gas chemistry (see Table 3.8). The oxygen-utilization rates measured at the site were varied, ranging from a slow rate of approximately 0.017% per hour at VPN20-57 to a high rate of approximately 1.4% per hour at VMP1-30. Oxygen-utilization rates at the remaining VMPs were not calculated either because the oxygen level was too low at the start of the ISR test or because the high initial oxygen level indicated little biological activity in those soils.

The air injected into the VMPs during the first and second ISR tests was, on average, a 3.3-percent and a 4-percent helium mixture in air, respectively. The helium is used both as a tracer gas and to evaluate the effectiveness of the bentonite seals in the VWs and VMPs. No appreciable loss of helium occurred at any VMPs where helium was injected between the end of injection and the final ISR readings taken after 28 hours of monitoring. Therefore, most of the oxygen loss observed during the ISR test was a result of bacterial respiration and not a result of either faulty well construction or overpurging of the VMPs during sampling.

Helium was also monitored at VW-18 and VW-19 and at VMPs where air injection did not occur. Detection of helium at these points provides some evidence that significant volumes of soil were aerated by the 1 scfm pumps and consistent helium levels at these points over time indicates that decreasing oxygen levels in extracted soil-gas are due to respiration.

Based on the measured oxygen-utilization rates and the laboratory analyses presented in Section 2.3, an estimated 40 to 2,500 mg of fuel per kg of soil can be biodegraded each year at this site. The lower estimate reflects the slow oxygen-utilization rate measured at VPN20-57. The higher estimate reflects the highest oxygen-utilization rate that was measured at VMP1-30. The locations with higher biodegradation rate estimates generally correlated to the locations with lower initial oxygen levels (prior to the AP test), although some of the points with lower biodegradation rate estimates also had lower initial oxygen levels. The biodegradation rate estimates are based on calculated air-filled porosities and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded.

Methods of calculation followed the procedures in the protocol document and are detailed in Appendix F.

Additional respiration testing at 6 months and one year following installation of the extended (one-year) pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.10 summarizes the data from the initial pilot test at SA 6.

### 3.3.5 Recommendations

Initial bioventing tests at SA 6 indicate that oxygen has been depleted in the contaminated soils and air injection is an effective method of increasing aerobic biodegradation of fuel contamination in the soil. AFCEE has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A 2.0-HP Gast™ regenerative blower (model R5) has been installed at SA 6 to continue a total rate of air injection of approximately 110 scfm into VW-18 and VW-19 at the site. The flow is balanced so that approximately 45% of the total air flow is injecting into VW-18, which has the shorter screen length, and 55% of the total air flow is injecting into VW-19, which has the longer screen length. In March 1994, ES personnel will return to the site to conduct a second respiration test. In September 1994, a final respiration test will be conducted and soil and soil-gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VWs and VMPs.

## 3.4 PRL T-46

### 3.4.1 Initial Soil-Gas Chemistry

Prior to initiating air injection, the VW and all VMPs were sampled using procedures described in Section 3.1.1. Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at the VW and at all VMP screened intervals, indicating soil contamination and natural biological activity at 5 to 40 feet bgs. The initial soil-gas chemistry measured at PRL T-46 is summarized in Table 3.11. TVH for soil-gas samples (both field instrument measurements and laboratory analytical results) and TRPH and BTEX concentrations for soil samples are also provided to demonstrate the relationship between depleted oxygen levels and the contaminated soils. Initial oxygen levels are also shown on the geologic cross-section for the site (Figure 1.12).

# Table 3.10
# PILOT TEST DATA SUMMARY
# SA 6
# McClellan AFB, California

| | Soil and Soil Gas Data | | | Air Permeability Test | | | | *In Situ* Respiration Test | | | | | Calculated Biodegradation Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Type | Laboratory Analytical Results | | Initial Soil Gas | | Final Soil Gas | Air Perm. | Initial Soil Gas | | Final Soil Gas | | $O_2$ Util. Rate | |
| WELL No.–DEPTH | | TPH–g (mg/kg) | TVH–g (ppmv) | $O_2$ (%) | $CO_2$ (%) | $O_2$ (%) | k (darcy) | $O_2$ (%) | He (%) | $O_2$ (%) | He (%) | $k_o$ (%/hr) | $K_b$ (mg fuel/kg soil per yr) |
| VW18–(25 – 100) | SAND | | 14,000 | 1.0 | 12.0 | | | 18.0 | 1.1 | 15.5 | 0.6 | 0.059 | 140 |
| VW19–(15 – 100) | SAND/SILT | | 55 | 16.5 | 2.5 | 19.0 | 13 | 17.5 | 1.0 | 8.5 | 1.0 | 0.24 | 490 |
| VMP1–17 • | silty CLAY/silty SAND | 1,210 | 130,000 | 1.2 | 15.2 | 4.0 | 24 | 19.8 | 4.8 | 7.5 | 3.9 | 0.42 | 620 |
| VMP1–30 • | silty CLAY | | | 1.0 | 12.2 | 11.5 | 14 | 19.2 | 4.5 | 3.0 | 2.9 | 1.40 | 2,500 |
| VMP1–54 | fine, med SAND | | | 10.5 | 5.5 | 20.8 | 12 | 20.7 | 0.04 | 20.0 | 0.17 | | |
| VMP2–19.5 • | clayey SAND | | | 1.2 | 20.0 | 1.5 | 22 | 19.8 | 4.0 | 8.5 | 3.7 | 0.41 | 720 |
| VMP2–30 | silty CLAY | | | 2.2 | 12.0 | 2.5 | 12 | 5.0 | 0.11 | 4.4 | 0.15 | | |
| VMP2–49 • | cly SILT/cly SAND | | | 3.0 | 9.2 | 7.0 | 12 | 19.5 | 4.2 | 15.0 | 3.2 | 0.15 | 220 |
| VPN20–24 • | fill: SAND | | 13,000 | 1.5 | 5.2 | 5.0 | 14 | 20.4 | 2.5 | 6.2 | 1.5 | 0.51 | 1,200 |
| VPN20–37 • | SAND | | | 1.0 | 11.8 | 2.0 | 13 | 20.4 | 2.6 | 17.2 | 2.5 | 0.11 | 260 |
| VPN20–49 | SILT | | | 3.0 | 11.0 | 17.5 | 12 | 11.2 | 1.8 | 5.2 | 1.7 | 0.22 | 390 |
| VPN20–57 • | SILT/CLAY | | | 1.5 | 7.5 | 18.0 | 12 | 20.0 | 2.7 | 19.6 | 2.5 | 0.017 | 40 |
| VPN20–75 • | SILT/CLAY | | | 3.0 | 8.8 | 8.5 | 11 | 20.0 | 2.9 | 18.6 | 2.1 | 0.056 | 130 |
| VPN20–99 | SILT/CLAY | | | 3.2 | 2.0 | 8.0 | 7.3 | 3.8 | 0.10 | 4.0 | 0.0 | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
ND : not detected
TPH–g : Total Petroleum Hydrocarbons as gasoline (mod. EPA 8015)
TVH–g : Total Volatile Hydrocarbons as gasoline (EPA TO–3)
• : VMP used for air injection during ISR tests
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. Air Permeability Test conducted at VW–18 for 9 hrs at air injection rate of 38 scfm.
2. First *In Situ* Respiration Test (at VPN–20 only): air injection at selected VMPs for 20 hrs at 1.1 scfm; $O_2/CO_2$/TVH measurements taken for 28 hrs following injection.
3. Second *In Situ* Respiration Test (other locations): air injection at selected VMPs for 22 hrs at 1.1 scfm; $O_2/CO_2$/TVH measurements taken for 28 hrs following injection.
4. Soil temperature (during second ISR test): 80.6 °F at VMP1–17; 80.4 °F at VMP1–54.

sa6tb310
01/26/94

# Table 3.11
# INITIAL CONDITIONS
# PRL T-46
# McClellan AFB, California

| | SOIL GAS | | | | SOIL | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Well No.- depth | $O_2$ (%) | $CO_2$ (%) | TVH-jf (ppmv) | TVH (ppmv) | TRPH (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) |
| VW1-(7 - 45) | 0.25 | 18.0 | 1,900 | 1,100 | 5,280 | ND | ND | 0.01 | 0.027 |
| VMP1-5 | 1.0 | 15.0 | | >10,000 | | | | | |
| VMP1-10 | 0.5 | 20.8 | 19,000 | >10,000 | 570 | ND | ND | 2.82 | 3.4 |
| VMP1-15 | 0.25 | 18.0 | | 3,300 | | | | | |
| VMP1-28 | 1.0 | 17.5 | | 800 | | | | | |
| VMP1-40 | 5.5 | 18.0 | | 140 | | | | | |
| VMP2-5 | 4.0 | 13.0 | | 84 | | | | | |
| VMP2-12.5 | 0.0 | 22.0 | | 520 | 3,320 | ND | ND | ND | 0.2 |
| VMP2-20 | 2.5 | 16.5 | | 52 | | | | | |
| VMP2-30 | 11.0 | 6.5 | | 105 | | | | | |
| VMP3-10 | 0.5 | 17.5 | 600 | 310 | | | | | |
| VMP3-18 | 4.5 | 16.0 | | 76 | | | | | |
| VMP3-30 | 9.5 | 9.5 | | 92 | | | | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TVH-jf : Total Volatile Hydrocarbons as jet fuel (EPA TO-3)
TVH : Total Volatile Hydrocarbons (THVA field instrument)
ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. $O_2/CO_2$ measurements by field instrumentation.
2. Soil sample was taken at a depth of 17.5 ft bgs at VW-1.
3. Benzene, Toluene, Ethylbenzene, and Total xylenes by EPA Method 8020.

t46tb311
01/26/94

### 3.4.2 Air Permeability

An AP test was conducted on 24 August 1993 according to protocol document procedures. Air was injected into VW-1 for approximately 5 hours at a rate of 41 scfm with an average pressure at the well-head of 36 in. $H_2O$. The dynamic pressure responses at the VMPs are shown on Figures D.12 through D.15 (see Appendix D).

Due to the relatively slow pressure response and the length of time required to achieve steady-state conditions, the dynamic response method was used to calculate air permeability values, as detailed in the protocol document. Calculated air permeabilities for each VMP and depth are shown on Figures D.12 through D.15. Permeability values ranged from 51 to 140 darcys, higher than expected for the very moist silty clays and fine sands which predominate at the site. With the exception of VMP2-5, significant pressure response was noted at all VMPs and at all depths. The lower pressure response at VMP2-5 is likely due to either the presence of fill material immediately above this point, which can provide preferential air flow paths, or because VMP2-5 is above the top of VW screen at 7 feet bgs. The permeability values indicate that the site soils are very permeable to air and should be sufficient for the bioventing technology.

### 3.4.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.12 presents the change in soil-gas oxygen levels during the AP test and after approximately two weeks of air injection. During the AP test, soil-gas oxygen levels were only measured at VMP-3 due to equipment problems. Although a significant oxygen increase was only measured at VMP3-30, the result provides some evidence of successful oxygen transport at a radial distance of at least 40 feet, even for the relatively brief injection period. The measurements taken after two weeks of air injection, however, confirmed that long-term oxygen response occurred at all points, except VMP2-5. This same location also showed the smallest pressure response during the AP test.

Based on measurable pressure response, which is an indicator of long-term oxygen transport, and the change in oxygen levels at two weeks into the injection period, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 40 feet from VW-1. The effective treatment radius will be better defined by monitoring the oxygen and contaminated soil-gas levels during the extended (one-year) pilot test at the site.

### 3.4.4 *In Situ* Respiration Rates

An ISR test was conducted at PRL T-46 between 25 and 26 August 1993, according to protocol document procedures. Air (20.8 percent oxygen) was injected at a rate of approximately 1 scfm into 4 VMP screened intervals (VMP1-10, VMP1-15, VMP2-12.5, and VMP3-10) for 21 hours in order to oxygenate surrounding soils. After air injection

# Table 3.12
# INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
# PRL T-46
# McClellan AFB, California

| Well No.– depth | Distance from VW-1 (ft) | Air Permeability Test Inital $O_2$ (%) | Air Permeability Test Final $O_2$ (%) | Long-term $O_2$ Response (%) |
|---|---|---|---|---|
| VMP1-5 | 10 | 1.0 | | 16.2 |
| VMP1-10 | 10 | 0.5 | | 16.2 |
| VMP1-15 | 10 | 0.3 | | 20.5 |
| VMP1-28 | 10 | 1.0 | | 19.5 |
| VMP1-40 | 10 | 5.5 | | 20.6 |
| VMP2-5 | 20 | 4.0 | | 2.5 |
| VMP2-12.5 | 20 | 0.0 | | 19.2 |
| VMP2-20 | 20 | 2.5 | | 20.0 |
| VMP2-30 | 20 | 11 | | 20.0 |
| VMP3-10 | 40 | 0.5 | 0.5 | 10.5 |
| VMP3-18 | 40 | 4.5 | 5.0 | 14.5 |
| VMP3-30 | 40 | 9.5 | 14.0 | 20.2 |

*LEGEND*

(shaded) : Sample was not taken/analyzed.
Air Permeability Test lasting 5 hours was performed on 24 August 1993.
Long-term $O_2$ measurements were taken on 9 September 1993.

t46tb312
01/26/94

was ceased, oxygen, carbon dioxide, and TVH levels in all VMP screen intervals (including those without air injection) were measured in soil gas for the following 15 hours. The results of the ISR test at PRL T-46 for 8 of the 13 monitored points are presented on Figures E.27 to E.34 (see Appendix E).

Results from the ISR test indicate that the shallower screened intervals (above approximately 30 feet bgs) generally had hydrocarbon contamination and active microorganism populations. Air was not injected at deeper monitoring points because initial oxygen levels were sufficient for aerobic biodegradation, and TVH readings indicated lower levels of contamination at the deeper points. With the exception of VMP3-18, oxygen-utilization rates measured at the site were moderate to high, ranging from approximately 0.41% per hour at VMP2-20 to approximately 1.8% per hour at VMP2-12.5. The oxygen-utilization rate measured at VMP3-18 was slow, approximately 0.03% per hour. Oxygen-utilization rates at the remaining VMPs were not calculated either because the oxygen level at the start of the ISR test was not significantly different than that measured initially (prior to the AP test) or because the high initial oxygen level indicated little biological activity in those soils.

The air injected into the VMPs during the ISR test was, on average, a 3.1-percent helium mixture in air. The helium is used both as a tracer gas and to evaluate the effectiveness of the bentonite seals in the VW and VMPs. No appreciable loss of helium occurred at any VMPs where helium was injected between the end of injection and the final ISR readings taken after 15 hours of monitoring. Therefore, most of the oxygen loss observed during the ISR test was a result of bacterial respiration and not a result of either faulty well construction or overpurging of the VMPs during sampling.

Helium was also monitored at VW-1 and at VMPs where air injection did not occur. Detection of helium at most of these points provides some evidence that significant volumes of soil were aerated by the 1 scfm pumps and consistent helium levels at these points over time indicated that decreasing oxygen levels in extracted soil-gas are due to respiration.

Based on the measured oxygen-utilization rates and the laboratory analyses presented in Section 2.4, an estimated 40 to 2,100 mg of fuel per kg of soil can be biodegraded each year at this site. The lower estimate reflects the slow oxygen-utilization rate measured at VMP3-18. The higher estimate reflects the lower moisture content and highest oxygen-utilization rate that was measured at VMP2-12.5. The locations with higher biodegradation rate estimates correlated well with the locations with lower initial oxygen levels and higher contamination levels in soil and soil gas. The biodegradation rate estimates are based on calculated air-filled porosities and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Methods of calculation followed the procedures in the protocol document and are detailed in Appendix F.

Additional respiration testing at 6 months and one year following installation of the extended (one-year) pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.13 summarizes the data from the initial pilot test at PRL T-46.

# Table 3.13
# PILOT TEST DATA SUMMARY
# PRL T−46
# McClellan AFB, California

| WELL No.−DEPTH | Soil and Soil Gas Data: Soil Type | Laboratory Analytical Results: TRPH (mg/kg) | Laboratory Analytical Results: TVH−jf (ppmv) | Air Permeability Test: Initial Soil Gas $O_2$ (%) | Initial Soil Gas $CO_2$ (%) | Final Soil Gas $O_2$ (%) | Air Perm. k (darcy) | *In Situ* Respiration Test: Initial Soil Gas $O_2$ (%) | Initial Soil Gas He (%) | Final Soil Gas $O_2$ (%) | Final Soil Gas He (%) | $O_2$ Util. Rate $k_o$ (%/hr) | Calculated Biodegradation Rate $K_b$ (mg fuel/kg soil per yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VW1−(7 − 45) | silty/clayey SAND | 5,280 | 1,900 | 0.25 | 18.0 | | | 10.0 | 3.9 | 2.0 | 2.1 | 1.3 | 770 |
| VMP1−5 | silty CLAY | | | 1.0 | 15.0 | | 101 | 6.5 | 3.5 | 0.5 | 2.0 | 0.53 | 460 |
| VMP1−10 • | clayey SAND | 570 | 19,000 | 0.5 | 20.8 | | 100 | 18.0 | 3.5 | 0.5 | 3.3 | 1.7 | 530 |
| VMP1−15 • | clayey SAND | | | 0.25 | 18.0 | | 140 | 19.8 | 3.6 | 6.8 | 3.2 | 0.89 | 1,300 |
| VMP1−28 | silty CLAY | | | 1.0 | 17.5 | | 51 | 5.0 | 1.0 | 0.8 | 0.43 | | |
| VMP1−40 | clayey SAND | | | 5.5 | 18.0 | | 51 | 18.0 | 0.16 | 16.5 | 0.23 | | |
| VMP2−5 | silty CLAY | | | 4.0 | 13.0 | | | 6.0 | 0.00 | 7.0 | 0.00 | | |
| VMP2−12.5 • | silty CLAY | 3,320 | | 0.0 | 22.0 | | 63 | 16.5 | 3.2 | 2.5 | 2.5 | 1.8 | 2,100 |
| VMP2−20 | fine/med SAND | | | 2.5 | 16.5 | | 60 | 17.0 | 2.6 | 12.0 | 1.8 | 0.41 | 360 |
| VMP2−30 | silty CLAY | | | 11.0 | 6.5 | | 53 | 7.5 | 0.41 | 6.8 | 0.40 | | |
| VMP3−10 • | silty CLAY | | 600 | 0.5 | 17.5 | 0.5 | 74 | 19.5 | 2.5 | 11.0 | 3.0 | 0.60 | 530 |
| VMP3−18 | clayey SAND | | | 4.5 | 16.0 | 5.0 | 65 | 12.5 | 1.5 | 12.0 | 1.7 | 0.03 | 40 |
| VMP3−30 | silty CLAY | | | 9.5 | 9.5 | 14.0 | 55 | 9.0 | 0.02 | 8.0 | 0.00 | | |

## *LEGEND*

(shaded) : Sample was not taken/analyzed.
TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TVH−jf : Total Volatile Hydrocarbons as jet fuel (EPA TO−3)
• : VMP used for air injection during ISR test

ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

## *NOTES*

1. VW−1 soil sample collected from 17.5 ft bgs.
2. Air Permeability Test conducted for 5 hrs at air injection rate of 41 scfm.
3. *In Situ* Respiration Test: air injection at selected VMPs for 21 hrs at 1.1 scfm; $O_2$/$CO_2$/TVH measurements taken for 15 hrs following injection.
4. Soil Temperature: 84.3 °F at VMP1−5; 72.6 °F at VMP1−40.

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01/26/94

### 3.4.5 Recommendations

Initial bioventing tests at PRL T-46 indicate that oxygen has been depleted in the contaminated soils and air injection is an effective method of increasing aerobic biodegradation of fuel contamination in the soil. AFCEE has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A small, 1.0-HP Gast™ regenerative blower (model R4) has been installed at PRL T-46 to continue a rate of air injection of approximately 68 scfm. In March 1994, ES personnel will return to the site to conduct a second respiration test. In September 1994, a final respiration test will be conducted and soil and soil-gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and VMPs.

## 3.5 Davis Global Communications Site (Davis Site)

### 3.5.1 Initial Soil-Gas Chemistry

Prior to initiating air injection, the VW and all VMPs were sampled using procedures described in Section 3.1.1. Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at the VW and at most VMP screened intervals, indicating soil contamination and natural biological activity at 10 to 50 feet bgs. The initial soil-gas chemistry measured at the Davis Site is summarized in Table 3.14. TVH for soil-gas samples (both field instrument measurements and laboratory analytical results) and TRPH and BTEX concentrations for soil samples are also provided to demonstrate the relationship between depleted oxygen levels and the contaminated soils (TVH levels are relatively low compared to other sites discussed previously because of the non-volatile nature of the diesel fuel contamination at the site). Initial oxygen levels are also shown on the geologic cross-section for the site (Figure 1.17).

The initial soil-gas chemistry measured at the background well (VMP-4) is also summarized in Table 3.14. Initial oxygen levels ranged from 16.5 percent to 18.0 percent. Therefore, according to protocol document procedures, an ISR test is required at the background well in order to perform any necessary corrections to oxygen-utilization rates. The background well ISR test will be conducted during the scheduled six-month ISR tests at the bioventing site. Although it cannot be assumed that no inorganic or natural carbon sources contributed to oxygen uptake during the ISR tests described in

# Table 3.14
# INITIAL CONDITIONS
# Davis Global Communications Site
# Davis, California

| | SOIL GAS | | | | SOIL | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Well No.– depth | $O_2$ (%) | $CO_2$ (%) | TVH–jf (ppmv) | TVH (ppmv) | TRPH (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) |
| VW1–(10 – 55) [1] | 0.3 | 4.0 | 84 | | 15,500 | ND | ND | ND | ND |
| VMP1–15 | 4.5 | 1.2 | | 110 | 1,370 | ND | ND | ND | ND |
| VMP1–25 | 1.5 | 3.7 | | 230 | | | | | |
| VMP1–37.5 | 1.0 | 6.3 | 380 | 140 | | | | | |
| VMP1–48 | 1.5 | 6.5 | | 340 | | | | | |
| VMP2–15 | | | | | | | | | |
| VMP2–32 | 4.0 | 7.8 | | 97 | | | | | |
| VMP2–43 | 3.5 | 6.0 | | 90 | | | | | |
| VMP2–49 | 0.0 | 6.8 | | 370 | 1,210 | ND | ND | ND | ND |
| VMP3–10 | 18.0 | 1.4 | | 46 | | | | | |
| VMP3–26.5 | 8.0 | 5.8 | | 67 | | | | | |
| VMP3–35 | 4.4 | 7.7 | | 76 | | | | | |
| VMP3–45 | 0.0 | 4.6 | 270 | 160 | | | | | |
| P5S–(18–20) | 20.8 | 0.3 | | 0 | | | | | |
| CH5–(28–38) | 0.0 | 8.5 | | 350 | | | | | |
| **Background Well** | | | | | | | | | |
| VMP4–15 | 16.5 | 0.9 | | 40 | | | | | |
| VMP4–30 | 18.0 | 1.5 | | 25 | | | | | |
| VMP4–40 | 17.5 | 2.0 | | 50 | | | | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.

TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)

TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)

TVH : Total Volatile Hydrocarbons (THVA field instrument)

ND : not detected

mg/kg : milligrams per kilogram

ppmv : parts per million by volume

[1] Soil gas readings for VW–1 taken on 27 August 1993, before blower startup but after initial pilot test.

*NOTES*

1. $O_2/CO_2$ measurements by field instrumentation.
2. Soil sample for VW–1 taken at a depth of 32.5 feet bgs.
3. Benzene, Toluene, Ethylbenzene, and Total Xylenes by EPA Method 8020.

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Section 3.5.4, the high oxygen readings from the background well indicate that any oxygen uptake contributable to inorganic or natural carbon sources is probably minimal.

### 3.5.2 Air Permeability

Two AP tests were conducted at the site between 18 and 19 August 1993. Both tests were conducted according to protocol document procedures. During the first AP test, air was injected at VW-1 at a flow rate of approximately 12 scfm. At the beginning of the AP test, very high well-head pressures (approximately 210 in. $H_2O$) and very low pressure responses at the VMPs were measured. Suspecting that the VW-1 borehole was smeared with wet clay during well construction, the blower was left running for approximately 19 hours. After 19 hours of air injection, a significant drop in the blower outlet pressure (down to 50 in. $H_2O$) was measured and it was assumed that extended venting had dried out the wet clay within the borehole. A second test AP test was then conducted for approximately 2 hours at a rate of 30 scfm with an average pressure at the well-head of 50 in. $H_2O$.

Due to the quick pressure response and the short length of time required to achieve steady-state conditions, the steady-state response method was used to calculate air permeability values collected during the second AP test, as detailed in the protocol document. Steady-state pressure responses and calculated air permeabilities with depth are shown on Figure D.16 (see Appendix D). The shallow points were defined as those above approximately 25 feet bgs; the medium depth points were defined as those between 25 and 35 feet bgs; and the deep points were defined as those below 35 feet bgs. Using these groupings, points were generally located within the same lithology at the site (see Figure 1.17). The medium depth points were located within sand-rich zones, whereas the shallow and deep points were in more clay-rich soils.

Using the steady-state method, permeability values ranged from 1.5 to 2.0 darcys, typical for the clayey soils at the site (shallow and deep points), although somewhat lower than expected for the sand interval, which occurs at approximately 25 to 35 feet bgs (medium points). Very low pressure responses were noted at all VMPs and at all depths, possibly due to preferential air flow within the more permeable sand interval or residual effects of the borehole smearing at VW-1. Nevertheless, the permeability values indicate that the site soils are probably sufficiently permeable to air for the bioventing technology.

### 3.5.3 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.15 presents the change in soil-gas oxygen levels during the time spanning both AP tests (approximately 18.5 hours) and after approximately two weeks of air injection. During the AP test, although two points near VW-1 showed significant increases in soil-gas oxygen levels (VMP1-37.5 and CH5), most points showed only a moderate increase, no increase, or a slight decrease (possibly due to displacement of

## Table 3.15
## INFLUENCE OF AIR INJECTION ON OXYGEN LEVELS
## Davis Global Communications Site
## Davis, California

| Well No.– depth | Distance from VW–1 (ft) | Air Permeability Test Inital $O_2$ (%) | Air Permeability Test Final $O_2$ (%) | Long–term $O_2$ Response (%) |
|---|---|---|---|---|
| VMP1–15 | 15 | 4.5 | 2.0 | 11.5 |
| VMP1–25 | 15 | 1.5 | 1.5 | 13.5 |
| VMP1–37.5 | 15 | 1.0 | 15.5 | 18.0 |
| VMP1–48 | 15 | 1.5 | 3.5 | 9.0 |
| VMP2–15 | 30 | | | |
| VMP2–32 | 30 | 4.0 | 5.2 | 20.5 |
| VMP2–43 | 30 | 3.5 | 6.0 | 18.0 |
| VMP2–49 | 30 | 0.0 | 1.0 | |
| VMP3–10 | 55 | 18.0 | 15.0 | 7.5 |
| VMP3–26.5 | 55 | 8.0 | 5.2 | 17.0 |
| VMP3–35 | 55 | 4.4 | 7.0 | 19.0 |
| VMP3–45 | 55 | 0.0 | 3.0 | 15.0 |
| P5S–(18–20) | 15 | 20.8 | 20.8 | |
| CH5–(28–38) | 18 | 0.0 | 19.2 | |

*LEGEND*

: Sample was not taken/analyzed.

Air Permeability Test lasting 18.5 hours performed on 18–19 Aug 1993.

Long–term $O_2$ measurements were taken on 8 September 1993.

davtb315

01/26/94

oxygen-depleted soil-gas). However, the measurements taken after two weeks of air injection confirmed that long-term oxygen response did occur at all but one of the measured points, as expected (a decrease was observed in VMP3-10). The highest soil-gas oxygen levels were observed within the more permeable sand interval between 25 and 35 feet bgs.

Based on the change in oxygen levels at two weeks into the injection period, it is anticipated that the radius of oxygen influence for a long-term bioventing system at this site will be at least 55 feet from VW-1. The effective treatment radius will be better defined by monitoring the oxygen and contaminated soil-gas levels during the extended (one-year) pilot test at the site.

### 3.5.4 *In Situ* Respiration Rates

An ISR test was conducted at the Davis Site between 19 and 21 August 1993, according to protocol document procedures. Air (20.8 percent oxygen) was injected at a rate of approximately 1 scfm into 4 VMP screened intervals (VMP1-25, VMP1-37.5, VMP2-49, and VMP3-45) for 21 hours in order to oxygenate surrounding soils. After air injection was ceased, oxygen, carbon dioxide, and TVH levels in all VMP screened intervals (including those without air injection) were measured in soil gas for the following 25 hours. The results of the ISR test for the Davis Site are presented on Figures E.35 to E.44 (see Appendix E).

Results from the ISR test indicate that most screened intervals had hydrocarbon contamination and active microorganism populations. Most of the oxygen-utilization rates measured at the site were moderate, ranging from approximately 0.09% per hour at VMP2-32 to approximately 0.44% per hour at VMP1-37.5. However, the oxygen-utilization rate measured at VMP2-49 was high, approximately 1.2% per hr. Oxygen-utilization rates were not measured at the remaining VMPs either because the oxygen level at the start of the ISR test was not significantly different than that measured initially (prior to the AP test) or because the high initial oxygen level indicated little biological activity in those soils.

The air injected into the VMPs during the ISR test was, on average, a 3-percent helium mixture in air. The helium is used both as a tracer gas and to evaluate the effectiveness of the bentonite seals in the VW and VMPs. No appreciable loss of helium occurred at any VMPs where helium was injected between the end of injection and the final ISR readings taken after 25 hours of monitoring. Therefore, most of the oxygen loss observed during the ISR test was a result of bacterial respiration and not a result of either faulty well construction or overpurging of the VMPs during sampling.

Helium was also monitored at VW-1 and at VMPs where air injection did not occur. Detection of helium at these points provides some evidence that significant volumes of soil were aerated by the 1 scfm pumps and consistent helium levels at these points over time indicates that decreasing oxygen levels in extracted soil-gas are due to respiration.

Based on the measured oxygen-utilization rates and the laboratory analyses presented in Section 2.7, an estimated 100 to 1,100 mg of fuel per kg of soil can be biodegraded each year at this site. The lower estimate reflects in part the slow oxygen-utilization rate

at VMP2-32. The higher estimate reflects the highest oxygen-utilization rate that was measured at VMP2-49. The locations with higher biodegradation rate estimates generally correlated to the locations with lower initial oxygen levels indicative of significant contamination in soil and soil-gas. The biodegradation rate estimates are based on calculated air-filled porosities and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Methods of calculation followed the procedures in the protocol document and are detailed in Appendix F.

Additional respiration testing at 6 months and one year following installation of the extended (one-year) pilot test system, and soil sampling one year following installation, will better define the long-term biodegradation rates. Table 3.16 summarizes the data from the initial pilot test at the Davis Site.

### 3.5.5 Potential Air Emissions

Air samples were taken at the ground surface at the Davis Site before and during air injection in order to evaluate the potential for discharge of petroleum hydrocarbons and chlorinated hydrocarbons to the atmosphere resulting from subsurface air injection. The results indicate that no significant increase in either TVH, BTEX, or chlorinated hydrocarbon levels above those found prior to air injection at the site are expected to occur during the extended (one-year) pilot test.

Six surface measurement points were located radially around the injection well (VW-1) and at distances expected to be under the influence of air injection. The surface points were arranged around VW-1 radiating outward in two arms of three points each. The arms were spaced roughly 120 degrees apart, one arm following a southern direction toward VMP-2 and the other arm following an eastern direction toward VMP-3 (see Figure 1.15). Additional surface measurement points were not necessary because the remaining part of the site was covered by asphalt. The points in each arm were spaced at 18, 36, and 55 feet from VW-1. Samples were collected as described in Section 3.1.5. Hydrocarbon concentrations were measured using both the THVA and laboratory analysis.

Results from the THVA were recorded in the field notebook and are shown in Table 3.17. All sample concentrations measured with the THVA were zero.

In order to determine the TVH-jf, BTEX, and chlorinated hydrocarbon content of potential emissions, two surface air samples were collected for laboratory analysis, one prior to air injection and one during air injection (3 hours after initiation of injection) at the same location (SPT4). The samples were collected in 1-liter Summa® cannisters immediately after the appropriate residence time was reached for the flux chamber (24 minutes) and shipped following procedures outlined in Section 2.1.3. Results of the laboratory analysis for the two samples were summarized in Table 2.7. The air injection flow rate during collection of the second surface air sample (SPT 4B) was approximately 54 scfm and the estimated radius of influence was approximately 55 feet. Because neither TVH-jf, benzene, or chlorinated hydrocarbon concentrations showed any appreciable increase during air injection above the background level measured prior to air injection, potential emissions due to air injection are expected to be negligible at the site.

# Table 3.16
# PILOT TEST DATA SUMMARY
## Davis Global Communications Site
## Davis, California

| | Soil and Soil Gas Data | | | Air Permeability Test | | | | In Situ Respiration Test | | | | | Calculated Biodegradation Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Type | Laboratory Analytical Results | | Initial Soil Gas | | Final Soil Gas | Air Perm. | Initial Soil Gas | | Final Soil Gas | | $O_2$ Util. Rate | |
| WELL No. – DEPTH | | TRPH (mg/kg) | TVH–jf (ppmv) | $O_2$ (%) | $CO_2$ (%) | $O_2$ (%) | k (darcy) | $O_2$ (%) | He (%) | $O_2$ (%) | He (%) | $k_o$ (%/hr) | $K_b$ (mg fuel/kg soil per yr) |
| VW1–(10 – 55) | SAND | 15,500 | 84 | | | | | 6.0 | 0.51 | 4.5 | 0.71 | | |
| VMP1–15 | sandy/silty CLAY | 1,370 | | 4.5 | 1.2 | 2.0 | 1.5 | 20.0 | 2.1 | 16.2 | 1.9 | 0.17 | 250 |
| VMP1–25 • | SAND | | | 1.5 | 3.7 | 1.5 | 2.0 | 19.5 | 2.3 | 9.2 | 2.5 | 0.36 | 620 |
| VMP1–37.5 • | clayey SILT | | 380 | 1.0 | 6.3 | 15.5 | 1.9 | 19.8 | 2.4 | 8.5 | 2.2 | 0.44 | 160 |
| VMP1–48 | CLAY | | | 1.5 | 6.5 | 3.5 | 1.9 | 18.8 | 2.1 | 7.1 | 2.3 | 0.40 | 690 |
| VMP2–15 | silty/sandy CLAY | | | | | | 1.5 | | | | | | |
| VMP2–32 | SAND/sandy SILT | | | 4.0 | 7.8 | 5.2 | 2.0 | 14.0 | 1.3 | 10.5 | 1.1 | 0.09 | 100 |
| VMP2–43 | silty CLAY | | | 3.5 | 6.0 | 6.0 | 1.9 | 19.0 | 2.1 | 14.0 | 1.3 | 0.22 | 260 |
| VMP2–49 • | silty CLAY | 1,210 | | 0.0 | 6.8 | 1.0 | 1.9 | 16.5 | 2.3 | 3.0 | 2.1 | 1.2 | 1,100 |
| VMP3–10 | sandy/clayey SILT | | | 18.0 | 1.4 | 15.0 | | 10.0 | 0.0 | 9.5 | 0.03 | | |
| VMP3–26.5 | clayey SAND | | | 8.0 | 5.8 | 5.2 | 2.0 | 18.0 | 1.4 | 12.0 | 0.82 | 0.23 | 270 |
| VMP3–35 | gravelly SAND | | | 4.4 | 7.7 | 4.2 | 2.0 | 20.0 | 2.1 | 15.5 | 1.1 | 0.20 | 350 |
| VMP3–45 • | silty CLAY | | 270 | 0.0 | 4.6 | 3.0 | 1.9 | 17.0 | 1.9 | 6.0 | 1.8 | 0.39 | 450 |
| P5S–(18–20) | sandy CLAY | | | 20.8 | 0.3 | 20.8 | | 20.5 | 0.0 | 20.5 | 0.02 | | |
| CH5–(28–38) | cly SAND/GRVL | | | 0.0 | 8.5 | 19.2 | | 5.0 | 0.0 | 1.0 | 0.12 | | |

*LEGEND*

(shaded) : Sample was not taken/analyzed.

TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)

TVH–jf : Total Volatile Hydrocarbons as jet fuel (EPA TO–3)

• : VMP used for air injection during ISR test

ND : not detected

mg/kg : milligrams per kilogram

ppmv : parts per million by volume

*NOTES*

1. VW–1 soil sample collected from 32.5 ft bgs.
2. Air Permeability Test conducted for 16.7 hrs at air injection rate of 30 scfm.
3. Air permeability values are based on steady–state response and represent an average value for soils at the site (see Figure D.16).
4. *In Situ* Respiration Test: air injection at selected VMPs for 21 hrs at 1.1 scfm; $O_2$/$CO_2$/TVH measurements taken for 25 hrs following injection.
5. Soil Temperature: 65.8 °F at VMP1–15; 65.6 °F at VMP1–48.

davtb316

01/26/94

# Table 3.17
# SURFACE AIR EMISSIONS
# Davis Global Communications Site
# Davis, California

| Location | Distance from VW-1 (ft) | Prior to Air Injection | During Air Injection (a) |
|---|---|---|---|
| | | TVH concentrations in ppmv | |
| SPT1 | 18 | 0 | 0 |
| SPT2 | 36 | 0 | 0 |
| SPT3 | 55 | 0 | 0 |
| SPT4 | 18 | 0 | 0 |
| SPT5 | 36 | 0 | 0 |
| SPT6 | 55 | 0 | 0 |

| *LEGEND* |
|---|
| TVH : Total Volatile Hydrocarbons (THVA field instrument)<br>ppmv : parts per million by volume<br>(a) : Sample collection begun approximately 3 hours after start of injection |

The long-term potential for air emissions during the extended (one-year) pilot test is also very low since the initial air injection probably displaced the highest concentrations of volatiles from the soil and the concentrations typically decrease with continued air injection. In addition, any accumulated petroleum hydrocarbon vapors in the pore space will be biodegraded as they move horizontally through the soil.

### 3.5.6 Recommendations

Initial bioventing tests at the Davis Site indicate that oxygen has been depleted in the contaminated soils and air injection is an effective method of increasing aerobic biodegradation of fuel contamination in the soil. AFCEE has recommended that air injection be implemented at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing soil temperatures on fuel biodegradation rates.

A small, 1.0-HP Gast™ regenerative blower (model R4) has been installed at the Davis Site to continue a rate of air injection of approximately 54 scfm. In March 1994, ES personnel will return to the site to conduct a second respiration test. In September 1994, a final respiration test will be conducted and soil and soil-gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on results presented by ES for the first year of pilot-scale bioventing, AFCEE will recommend one of two options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and VMPs.

## 4.0 REFERENCES


Hinchee et al. 1992, Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, U.S. Air Force Center for Environmental Excellence (AFCEE). January

U.S. Environmental Protection Agency (USEPA) 1986, Measurement of Gaseous Emission Rates from Land Surface Using an Emission Isolation Flux Chamber: User's Guide, EPA/600/8-86/008, February